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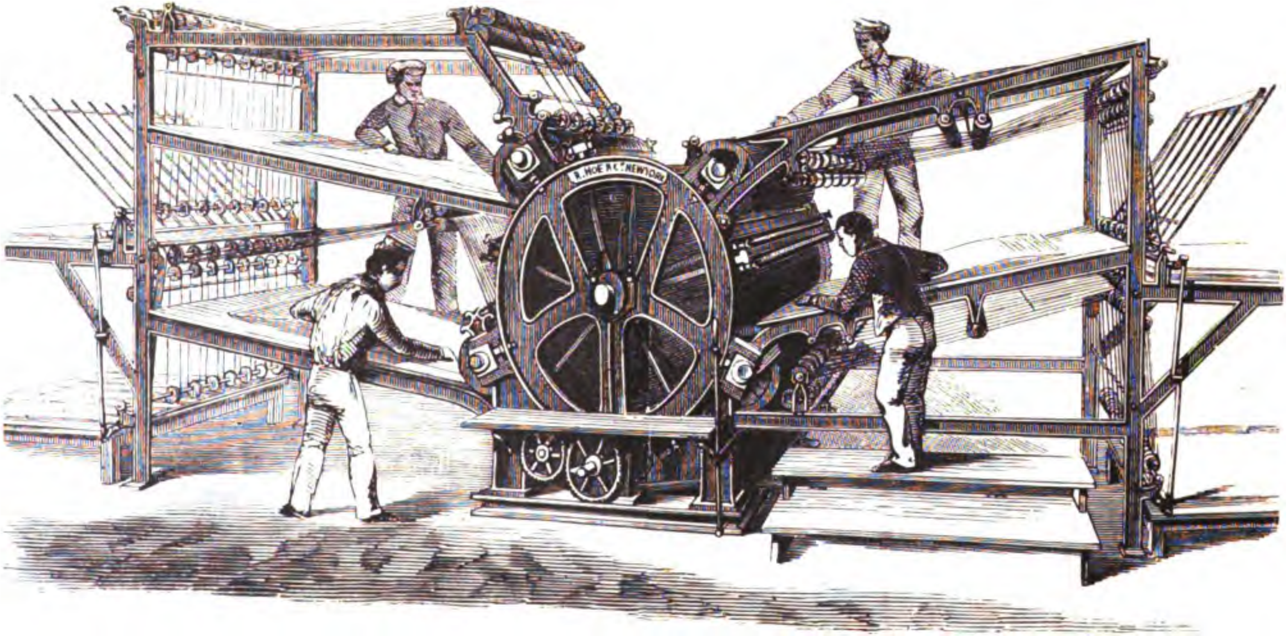
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OF

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INCLUDING

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MACHINERY, MANUFACTURES, MINING, PHOTOGENIC
AND TELEGRAPHIC ART:

BEING

AN EXPOSITION OF THEIR PRINCIPLES AND PRACTICE AND A COMPEND OF
AMERICAN AND EUROPEAN INVENTION.

BY

T. ANTISELL, M. D.

NEW-YORK:
GEORGE P. PUTNAM.
1852.

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P.7

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PREFACE.

The aim and scope of this volume is perhaps sufficiently indicated in the title-page. It is intended to comprise, in a clear and comprehensive form for popular reference, a dictionary of all terms used in the application of science to the useful arts. It is believed that a manual of this kind—sufficiently full in its details for ordinary purposes, and accurately posted up to the present time, yet in a comparatively moderate compass—will meet a very important want in this country, which is yet unfilled by the larger and more expensive works already before the public.

The number of new inventions of various sorts constantly brought forward in the United States is so enormous, and the proportion of those which prove really valuable is so small, that it would be needless in a volume like this to attempt any thing more than a reference to the most important and established improvements. The number of applications for patents in the year 1849 was 1955,—of which 1066 were granted. The editor of this volume has endeavored to condense in its pages as much practical information as the limits of the work would admit, from various recent sources, such as the reports of the Patent Office, and the scientific periodicals, as well as from the standard works of Brande and Ure. He has, in short, combined the best foreign information at present accessible with the latest details of the progress of the Useful Arts in the United States.

In some few instances, this work contains topics which are also treated of in the other volumes of the series: but in this volume practical details are given, while the others are intended to give merely the scientific definitions.

It is not to be supposed that infallibility is claimed for a compilation of this kind. Every care has been used to secure accuracy, but the publisher will still be glad to avail himself, in future editions, of all useful suggestions and corrections with which he may be favored.

CYCLOPEDIA

OF

THE USEFUL ARTS.

ACETATE. A saline compound formed by the union of an alkali, or an earth with Acetic Acid.

ACETIC ACID. The sour principle of vinegar. This acid occurs in the vegetable kingdom in the elder and some varieties of rhus. It exists in the gastric juice and other animal secretions. When vegetable matter is distilled in close vessels, this acid is always one of the products. Alcoholic liquids are capable of producing acetic acid, and it is the last stage in the fermentation of many vegetable bodies containing starch or sugar—as paste, &c. Pyroligneous acid is acetic acid derived from wood—for the manufacture of which see under that head. The purest acetic acid is that made by the oxydation of alcohol. The oxydation is produced by the action of the atmosphere. In Germany, where this process was first adopted, the alcohol was exposed in very large surface to the action by being made to trickle along the shavings of wood. These were placed in a deep barrel, perforated at the sides with a number of holes so that free access of air to the inside of the vessel was effected; on the upper part of the barrel was a raised rim capable of holding a certain head of alcohol, and the upper end of the barrel was perforated with a few fine apertures so that the alcohol might slowly stream down on the shavings; it was thus exposed to a large quantity of air constantly renewed, and by the time it reached the bottom of the vessel it was converted into vinegar, or dilute acetic acid. It was drawn off by a cork from the lower part of the barrel, placed in a still and distilled with a gentle heat; the portions which come over first, contain the acetic acid.

A great improvement on this process has been the substitution of spongy platinum (see Platinum) for the wood shavings. The principle in both is the same, being the oxydation of alcohol by the air. Into a large case of wood with glass sides or windows for observing the process, and fitted with shelves within a few inches of each other, is placed a number of saucers filled with the alcohol, and over each saucer is suspended a small portion of the black platinum powder. The quantity of alcohol in the saucers varies with the dimensions of the case; 100 cubic inches of air being capable of oxydizing 11 grains of absolute alcohol, and converting it into 12·2 of absolute acetic acid and 6¼ grains of water. The case must now be warmed up to 80° Fahr. by solar or artificial heat and the alcohol induced to evaporate off the saucers by some leading points, as strings or folds of paper set endways in the liquid: in a short time the temperature inside the box rises; vapors form, condense on the inside, and roll down to the bottom. This process continues so long as there is any oxygen of the air in the vessel unconsumed: now and then fresh supplies of air are needed—8 oz. of the platinum powder will in a day's work convert one pound of alcohol into acetic acid. The change arises from the absorption of oxygen from the air, and its union with the elements of alcohol, which results in the formation of acetic acid and water. By the chemist the change is expressed by the formula: alcohol $C^4 H^6 O^2$ + O^4 from air = $C^4 H^3 O^3$ acetic acid + $3 H O$ water. Hence 100 parts of alcohol absorb nearly 69 parts of oxygen, and there are produced nearly 111 parts of acetic acid and 58 parts of water. Strong acetic acid is also made by distilling crystalled bin-acetate copper (verdigris) in close vessels at a high heat. It can also be made by distilling acetate of potass and acetate of lead (sugar of lead) with oil of vitriol. In its purest state it is united with an atom of water, and has a specific gravity of 1·063. It is caustic on the tongue and to the skin: it is used as a scent, and when essential oils are added, constitutes the aromatic vinegar. It dissolves camphor, gluten, resins, gum resins, fibrine, and albumen.

ACETONE. A term for pyro-acetic spirit.

ACIDS. A class of chemical substances remarkable for their sour taste and their readiness to unite with alkalies and earths to form salts: there are many hundred acids, distributed in the three kingdoms of nature. With one exception they redden vegetable blue colors, as blue cabbage and litmus. Some exist naturally in the mineral, animal, and vegetable world, and some are the result of chemical processes: a few are solid bodies and some gaseous, but the greater number are in the liquid form.

ACTINOLITE. A hornblend mineral of a green tint, and crystallized in slender needle prisms.

ADIPOCIRE. The change which flesh undergoes after death when placed in circumstances where putrefaction does not proceed in the ordinary way. In Paris, when in the latter quarter of the last century the dead bodies were removed from the *Innocents* to the Catacombs, those which lay in a pit—to the number of 1500, in coffins packed close together—had their flesh converted into a white fatty soap: it resembled spermaciti, and was named adipocire by Fourcroy. Chevreul found it to be made up of fatty acids. Moisture appears to be necessary to produce this substance, as it is not produced in dry earth: and it is very doubtful if it be formed from the muscle of man, but rather some alteration of the fat actually existing in the body at the time of death.

ADULARIA. A variety of felspar.

AFFINITY. A term denoting the force of chemical attraction by which dissimilar bodies are brought into union and retained so. It is distinguished from cohesion, which is exerted between bodies of a similar nature. Cohesion is a force antagonistic to affinity, and for two dissimilar substances to unite it is necessary that one of them should be fluid: if both be fluid, affinity comes into play more readily, as in the case of alloys: dissolving the substances in some special liquid, or heating them until melted, are the modes of bringing the particles of matter sufficiently close to form chemcal union. Every process of chemical manufactures implies the union and decomposition of bodies, which are effected by calling into play their affinities. Many bodies, although dissimilar, have no tendency to unite—as oil and water, mercury and water, mercury and oil. This is explained by saying that these bodies have no affinity for one another: while alcohol and water, sulphuric acid and potass, oxalic acid and lime, unite readily because their mutual affinities are strong.

ADHESION. That property possessed by bodies of dissimilar natures of resisting a force applied to separate them; and it differs from *cohesion* and *affinity*. Adhesion cannot occur between two solid bodies, for then the force which binds them together is either some modification of the attractive force, or it is due to atmospheric pressure: for perfect adhesion, one of the bodies ought to be fluid or semifluid; it may afterwards return to the solid condition without destroying the adhesion, unless it crystallize. It is desirable also that they should not contract unequally in cooling, for then the adhesion would be destroyed: for the union of two surfaces into one it is therefore necessary that both should contract equally: and cement for uniting different surfaces depends for its fitness upon this property: to cement metals with other solids, solders are needful, and particular solders for various metals. Such bodies as pitch, which even at reduced temperatures will expand, are those which adhere most firmly. The adhesion between solid bodies is sufficiently strong to overcome the cohesive force of one of them—as when two pieces of wood are glued together and then separated forcibly, a layer of glue remains on each piece. The adhesion of the wafer on the envelope is greater than the cohesion between the particles of the paper, and a layer comes off on the surface of the wafer when the latter is separated. When a solid dips in a liquid, its adhesion is sometimes greater than the cohesion for the particles of the liquid, as when wood or metal is dipped into water: the water adhering is said to *wet* it. Wood or the finger, dipped into quicksilver, is not *wetted*. Oils have no adhesion for water. (For other instances of adhesion, *see* CEMENTS.)

ADZE—ADDICE. A cutting chisel with an arched blade and the edge at right angles to the handle: it differs from the chisel in application, the force being impact and arising from a blow and not that of mere pressure. The adze cuts the wood, if its edge be fine; but if not, the wood is split and the tool acts then more like the axe as a wedge than the chisel. In coarse preparatory work, the adze is carried through the space between the workman two feet, and the quantity of wood removed is very great; in fine work, the foot is placed upon the wood and the adze is carried two or three inches under the sole, and the smoothness and delicacy of the work accomplished is surprising.

AERATED WATERS. Artificial drinks impregnated with carbonic acid—as soda water, ginger beer, carrara water, &c.

AGARIC. A species of fungus or puff-ball; occasionally used as a tinder and as a black dye in combination with per-salts of iron.

AGATE. A name given to many combinations of chalcedony, carnelian, quartz, amethyst and flint. It is one of the varied forms of silicious minerals, and contains 98 per cent. of silica; it is opaque, and has a resinous fracture with deep tints, produced by traces of iron. When a section is made it displays a series of dark lines or bands, sometimes irregular, sometimes rounded, which are the edges of successive deposits made by the mineral during its formation. Agates take a high polish, and are much valued as ornamental stones in the manufacture of cups, rings, seals, knife-handles, snuff-boxes, &c.; burnishers are made of agate for the use of bookbinders and silversmiths. These gems occur naturally in amygdaloid trap rocks, lying in nodules, surrounded by chloritic clay, also in beds of streams and rivers, where they have been washed down. They are made darker in tint by being boiled in oil, and then dipped in oil of vitriol. The carnelian is an agate of a flesh red or yellow tint: it is common in the sandy plains of Africa, India, and Asia Minor.

AIR. The gaseous envelope of the earth. Our planet has two coverings: one the water which is distributed as lakes and seas, filling up the deep cavities of the solid surface, tending to produce a more level superficies; the second covering is the air or atmosphere which rests upon the top of the water and the dry land, enveloping the highest mountains, and rising upwards to an altitude somewhat above 45 miles; it is a true aeriform ocean surrounding our earth, and has upon its upper surface waves and tides, and throughout its mass, currents flowing in constant and variable directions, precisely as those of the ocean comport themselves; it is held down to the surface of the earth by attraction, and rotates with the planet; its density varies with its actual height at the place of observation, of which the barometric pressure is the evidence. This pressure diminishes as the elevation above the sea increases, owing to the upper portions of the atmosphere pressing upon and condensing the lower strata so much so, that one-half the actual weight of the atmosphere is comprised within the space of the lower 5 miles of its total height, the remaining 40 miles in height containing the other half. The air is highly compressible and elastic, and its volume diminished inversely as the pressure increases. This accounts for the facility of setting it in motion and its velocity. Like fluids, it presses equally in every direction, and when it comes in contact with a more expanded, and therefore lighter portion of air, it pushes it up and occupies its place, producing currents of air and winds when it flows in streams, and sound when it is thrown into vibrations or undulations. The air is warmed solely by the earth, and not by the transmitted rays of the sun,—hence warm air exists within the tropics, and diminishes toward the poles, and sensibly decreases every 350 feet of elevation. Air was one of the simple substances of the ancient philosophers; but it has been shown by Scheele and Cavendish to be a compound body made up of oxygen gas and nitrogen. The proportions in which they are found to exist, are 21 of oxygen and 79 of nitrogen by volume in 100 parts. These substances are not chemically united, they are merely mixed together. There is also contained in the atmosphere a small quantity of carbonic acid, amounting to one twenty-five hundredth part, which, no matter at what elevation the air may be drawn, is still found. Saussure detected it at Mont Blanc, and Boussingault on the Andes, so that it is a regular constituent. Liebig has shown that ammonia can also be detected in the atmosphere, to which may be added a variable quantity of watery vapor, odors of plants, and other volatile substances; it no doubt also contains floating particles (miasmata), during periods of epidemic disease. The chemical properties and the beneficial effects of the air are due to the pressure of oxygen, the removal of which, or any alteration of its amount and condition, renders the air injurious to life. (*See* VENTILATION.) Although air is invisible, and much lighter than solid or fluid bodies, yet it is still subject to all the physical laws which govern gases; in a large quantity, as when the sky is clear, it gives us a blue tint to the eye, which may be due to the vapor of water in the atmosphere refracting the light. It occupies a given space, and is impenetrable, and no other substance can occupy where it is except it be by displacement. It is capable of communicating weight: and 100 cubic inches of it are found to weigh 31·0117 grains at the temperature of 60°, and the barometric column standing at 30°. This weight is equal, on the whole atmosphere of 45 miles height, to a pressure of 15 lbs. on every square inch. This pressure varies in different places and at different times. (*See* BAROMETER.) This pressure is exerted upon every substance at the level of the sea. Air may be compressed into a smaller volume, in proportion to the pressure exerted upon. Doubling the pressure condenses the air into one-half its bulk; when released from pressure it expands to its original bulk: this is due to its elasticity, which, like all gases, is very great.

AIR-PUMP—EXHAUSTING SYRINGE. Instruments founded upon the elastic property of the air. The syringe consists of a brass cylinder with an air-tight piston; a valve at the top opens upwards into the body, and one at the lower part opens outward (at the side) into the external air. This apparatus is screwed on to any vessel which requires to have the air removed. On raising the piston the air from the vessel below follows it upward, filling the cylinder; if the lower stopcock be now closed, and the cylinder pressed down, the air will escape by the valve at the side, and the cylinder can be emptied in this way. By constant repetitions of raising the piston, and then expelling the contained air of the cylinder, the greater part of the air of the attached vessel is drawn up and removed. The whole air cannot be discharged in this way: for after it has been worked some time, and the greater quantity of air discharged, the elastic force of the remainder is so slight as not to be able to raise the valve. The air-pump is a doubly exhausting syringe, which has its valves in the piston or plug. There are two moving in the cylinder or barrels, with a reciprocating motion communicated by a toothed wheel and racked piston rods. The barrels communicate by means of a tube with a table of metal, upon which is fixed a bell-glass or receiver, made stoutly, and with a strong rim at the bottom ground finely, so as to fit smooth on the table; a a little tallow or fat is used to smear the table to make the fitting more tight. The receiver is thus a transparent air-tight chamber in which any object may be placed from which it is needful to remove air. A stopcock is fitted to the connecting tube, to shut off or let on external air when desired. To good air-pumps a mercurial gauge is attached.

AIR-BEDS. Another application of the elasticity of the air to supply the padding or stuffing material of pillows, cushions, and beds, by the use of air, instead of solid substances: a bag of cloth is rendered air-proof by means of a varnish of India-rubber or gutta percha, a tube and stopcock are affixed to one corner, through which the air is blown in to inflate the bag. When moderately distended with air these beds and cushions are tolerably soft. The objection to these is that they warm too soon—the heat of the body accumulates in the pillow, the air of which is a non-conductor.

AIR-GUNS are syringes used for condensing air, acting somewhat similarly to the exhausting syringe. In the air-gun the vessel for holding the air is a small metal ball, having a small hole and valve turned inwards. The ball is screwed on to a barrel fitted with a bullet, when upon turning a cock, communicating between the condensed air and the bullet, the latter is driven out with great velocity. To condense the air requires the syringe to act in the reverse manner to that used for exhaustion.

ALABASTER. A term sometimes applied to stalactitic carbonate of lime. By the ancients was understood small white stone vessels of a peculiar form, made at Alabastron in Egypt: it is now generally applied to that variety of sulphate of lime, known as granular gypsum, used for carving small statues, groups of figures and animals, and boxes and vases, which are turned in a lathe. For these purposes it is well adapted by its whiteness, translucency and softness. The best is quarried near Volterra in Tuscany. In this duchy are the hot springs of San Filippo, where the water, almost boiling, contains in solution a large quantity of carbonate of lime, held dissolved by sulphureted hydrogen, which escapes as soon as the water is exposed to the air. Advantage is taken of this property to make bas-reliefs of much hardness, by placing moulds of sulphur obliquely in wooden tubs, open at the bottom. The water of the spring, after depositing its turbid matter, is conveyed above those tubs, which have affixed to their top wooden cross-pieces, the water is allowed to fall upon them, and is then poured in fine streams over the moulds hanging below. From two to four months are required for obtaining castings.

ALCARAZZAS. A species of porous earthenware used in Spain for cooling liquors.

ALBUMEN. The white portion of the egg is in great part albumen. It is also a constituent of the fluid portion of the blood, and of the sap of some plants, as potato, parsnip, carrot, in the seeds of the cereals, and in most nuts. The characteristic property of albumen, under any circumstance, is its coagulating at a temperature about 160° Fahr. When pure, vegetable and animal albumen are the same substance. That from the egg soon putrefies in the air; but if it be spread out in thin films, it dries readily, and may then be preserved unaltered for any length of time. Once coagulated, albumen will not dissolve again in water, but is soluble in caustic alkalies. The solidification of albumen is believed to be due to the loss of alkali, dissolved out by the boiling water. From having this property, albumen is used to clarify syrups, coffee, &c. It is also coagulated by alcohol, the majority of acids, except the acetic, which dissolves it, and by a few metallic salts, such as corrosive sublimate, for which it is an antidote. Lime, baryta, and strontia, form compounds with albumen, which harden in drying, and become good lutes or cements for china or glass, or spread on paper for chemical apparatus.

ALCOHOL. The liquor procured by distillation of vegetable infusions of a saccharine nature, and juices which have passed through the vinous fermentation. Ordinary alcohol is not pure, containing usually half its weight of water, from which it may be freed by redistillation at a gentle steam or water-bath heat, until its specific gravity is ·830. To free it perfectly, it is necessary to add into the still, or retort, caustic lime, calcined pearlashes, or fused chloride calcium; it is then perfectly free from water, and has a specific gravity of ·793; it then boils at 169° Fahr. Alcohol may also be concentrated by exposing it in ox bladders, owing to the property which the latter possess, of allowing water to pass through the pores and evaporate out, but giving little or no facility for the vapor of alcohol to escape. Both surfaces of the bladder should be soaked in water, and freed from fat and minute vessels adhering on both the outer and inner surfaces; it then should get a couple of coats of a solution of isinglass on the outer, and double the number on the inside surface; the spirit is then poured in, but the bladder not quite filled by it, a portion of air occupying the top; it is then tied tightly at the mouth, and hung in a warm place near a stove or oven. In this way alcohol may be concentrated in twelve hours, and this kind is well adapted for varnishes. Alcohol has a great attraction for water, and if left exposed, rapidly attracts moisture from the air: it should therefore be kept in well closed vessels. From this property it is well adapted for preserving anatomical specimens. It has the property of dissolving many substances, as soap, camphor, resins, essential oils, castor oil, forming varnishes, essences, perfumes, and extracts. If these solutions be mixed with water, milkiness or opacity is produced, owing to the alcohol separating these substances, by preferring to unite with the water. The strength of alcohol is determined by instruments which read off its specific gravity, calculated tables for which may be found in more technical works. The instruments are termed alcoholmeters, hydrometers. Gay-Lussac's instrument, the "alcoometre," is probably the instrument yielding the most correct results: absolute alcohol consists chemically of 4 atoms of carbon, 6 of hydrogen, and 2 of oxygen.

ALE. Infusion of barley and infusion of hops, fermented together.

ALEMBIC. A vessel used in distillation, for receiving the liquid to be distilled.

ALEMBROTH SAL. An old term for white precipitate of mercury, or the double chloride of mercury and ammonia.

ALIZARINE. One of the principles of the madder plant: from which it may be obtained by charring the powder root with oil of vitriol, washing the black mass well with water, drying and heating, when alizarine is obtained in crystals of an orange-red color.

ALKALI. A name first applied by the Arabians to the carbonates of soda and potash derived from the ashes of plants, but now extended to those substances which dissolve in water, generally form soaps with oils, and neutralize acids forming crystalline salts. The chief alkalies of importance in the arts are potash, soda, ammonia, and quinia. They have a common effect upon some colors—such as turning the red colors of roses, cabbages, and radishes to green, the red of litmus to purple, and the yellow of turmeric and a few other vegetable dyes to brown. Even when these three first named alkalies are united with carbonic acid, they exert the same reaction, by which they are readily distinguished from lime and magnesia. When pure they have an acrid and urinous taste, dissolve animal matter readily, and unite with oils: they also unite with water in any proportion. A strong solution in water is termed a *lye* or *ley*.

ALKALIMETER. An instrument used for testing the strength of the alkalies of commerce. The operation is termed *alkalimetry*, the general principle of which consists in ascertaining the quantity of real alkali in a given weight of the substance examined, by finding how much of the latter is required to neutralize a known quantity of an acid—as sulphuric acid. The first step is to prepare a stock of dilute sulphuric acid of a known strength, containing for example, 100 grains of real acid in every 1000 grain measures of liquid. A large quantity—as a gallon or more—may be prepared at once: thus, the oil of vitriol, if it be good and of the specific gravity of 1·85, contains in every 49 grains 40 grains of absolute acid. For the proportion required above—every gallon or 70,000 grains of dilute acid—7000 grains of real or absolute acid is demanded; this, at the composition of the acid given, is equal to 8571 grains of common oil of vitriol. All that is required, is then to weigh out 8571 grains of vitriol and dilute it with water until when cool the mixture shall measure exactly one gallon.

The "Alkalimeter" is next to be constructed out of a piece of even cylindrical glass tube, fifteen inches long and six-tenths of an inch wide internally, closed at one end and moulded into a spout or lip at the other; a strip of paper is pasted on the tube and suffered to dry, after which it is graduated by counterpoising it in a nearly upright position in the pan of a delicate balance, and weighing into it successively one, two, and three hundred grains of distilled water at 60° until the whole quantity of 1000 grains be reached, the level of the tube after each addition being carefully marked with a pen upon the strip of paper while the tube is held quite upright and the mark made between the top and bottom of the curve formed by the surface of the water. The smaller divisions of each hundred parts may then be made with the compass into tenth parts. The graduation being accurate and complete, the operator may transfer the marking to the glass by means of a file, and the paper may be removed with hot water. The numbers can be scratched with the hard end of the file. When this instrument is used with the dilute acid above, every division of the glass will correspond to one grain of real acid.

The alkali is examined thus: 50 grains of the sample are weighed, dissolved in warm water, and if needful, filtered: the alkalimeter is then filled to the top of the scale with the dilute acid, and the latter poured from it into the alkaline solution, which is tried from time to time with red litmus paper. When the solution, after being heated a few minutes, no longer affects either blue or red litmus, the measure of liquid employed is read off, and the quantity of soda or potass present in the state of carbonate or hydrate in the 50 grains of salt, is found by the rule of proportion. Suppose soda was the alkali, and that 33 measures of acid had been used; then by taking their atomic proportions in which the acid and soda unite, it would stand thus: as

Sulph. acid 40 : soda 31·9 : : 33 : 25·6

in 50 grains. The sample therefore contains 51·2 per cent. of available alkali. The quantity of alkali in a carbonated form may be known by weighing the body before and after the expulsion of carbonic acid; from the loss may be calculated the per centage of alkali. By the use of Fresenius's apparatus for this purpose, the precision attained leaves nothing to be desired.

ALKALOID. Alkalies found existing in vegetables united with peculiar acids. They are produced by the plant during growth. They dissolve readily in boiling alcohol, and sparingly in water: they crystallize out of the alcohol by cooling the latter, from which they can be separated in a crystalline form; they restore the blue color to red litmus, and render yellow turmeric brown. The chief alkaloids are quinine and cinchonine from Peruvian bark, nicotine from tobacco: morphia, codeine, narcotine, thebaine, from the papaveraceæ; and in other families, strychnine, atropine, brucine, veratrine, emetine, berberine, and cafeine. They all contain nitrogen not existing in the form of ammonia.

ALKANET. A root used for dyeing red. The plant, *anchusa tinctoria*, belongs to the family Boragineæ, and is a species of bugloss, cultivated largely in the south of France: the roots yield a deep red to alcohol and oils, and a dull red to water. It is used extensively to color ointments, oils, cheese, and perfumery in general. White marble is stained a deep tint by the alcoholic solution.

ALLOY. A compound formed of two or more metals fused together. Thus bronze is an alloy of copper and tin; brass an alloy of copper and zinc: they all have lustre, are sonorous, elastic, ductile, and malleable, like simple metals. Metals do not alloy indifferently with each other, but are governed by peculiar affinities. Silver unites readily with lead, copper, and gold, but will scarcely alloy with iron. When a metal is united with mercury, it generally receives the title of an amalgam. When metals are united in an alloy the specific gravity of the new compound is not the mean of its constituents, but occasionally is greater —in other instances, less: its melting point also is not the mean of the melting points of the two metals, but it is generally somewhat lower in temperature—the fusibility of an alloy is increased. Although the number of metals is very great (43), yet only a few are extensively found or of much use—perhaps the number frequently employed is not more than twelve: where purity of a metal is not required, but some property which a single metal does not possess, an alloy is found to supply the want. Even the property of an alloy itself may be varied by uniting with a portion of a third metal. Thus in the case of the alloy brass; when it is required to have brass fit for turning, a small quantity of lead is added. This improves it for that purpose, but renders it unfit for hammering. The number of useful metals can be thus multiplied, as it were, by the formation of alloys.

Alloys can only be properly formed by fusion, as by melting the two metals together in a crucible. They require to be stirred well while melting, lest the metals separate from each other, the heavier taking the bottom of the vessel. The strength or cohesion of alloys is greater than that of its constituents. The most refractory metals, which can scarcely be fused in a crucible at the greatest heat of the furnace, melt down with ease when surrounded by the more fusible metals. The surfaces of the superior metal are melted down or washed away, layer by layer, until the whole becomes liquified. Nickel is nearly as difficult to melt as iron; but it is usefully employed with copper in German silver, to which it gives whiteness and hardness, and renders the alloy less fusible. Platinum cannot be melted at the highest heat of a furnace, but it combines so readily with zinc, tin, and arsenic that it is dangerous to heat one of these substances in a platinum spoon, for an alloy would be formed and the spoon destroyed.

An alloy, remarkable for its easy fusibility, is made by melting together eight parts of bismuth, five of lead, and three of tin. This melts in boiling water, even in water of the temperature 198° Fahr. It is on this account called *fusible metal.* The proportions may be varied to make a more or less fusible compound. Safety plugs for valves of steam-boilers, are made of this material: a hole made in the boiler is stopped with one of these plugs, so that when from any derangement of the valve steam above the usual pressure and temperature be formed, it would melt the plug and force its way out through the aperture rather than burst the boiler. When quicksilver is added to this alloy, it becomes more fusible; and is used by dentists for stuffing decayed teeth.

Solders are alloys, and generally contain a portion of the metal they are used to connect. (*See* SOLDER.)

ALMOND OIL. A bland, fixed oil, obtained from the seeds or kernels of bitter almonds, either by subjecting them to pressure in a hydraulic press in the cold, or by the aid of hot iron plates.

ALUM. One of the most useful salts manufactured; it is extensively employed in dyeing and calico-printing, to which it supplies the mordant. In candle-making, it is used to harden and whiten tallow; in bread-making, it is often used for a similar effect; it is added to paste to prevent its decomposition; it is employed in preparing and preserving skins, and also in pharmacy. Our alum was unknown to the ancients, who under that name used a different substance, as sulphate iron, or the latter mixed with alum earth. Alum is composed of sulphuric acid, alumina, or the earth of clay and potash. It is a double sulphate of alumina and potash. Crystals of alum are sometimes found ready formed in the earth, as along the chain of the Andes—as aluminite in Germany, New-York, and other parts of the United States. The materials for alum are, however, found in a state of combination almost fit for manufacture into alum in various parts of the world. In Italy, Hungary, Sweden, Scotland, and North of England, there are rocks and earths termed alum stone—alum slate, A. clay, slate clay, and bituminous shale. These furnish the main material, and when treated in various ways yield the greater part of the alum of commerce. These clays and rocks are abundant in this continent. The Genesee black slate of the New-York system of rocks is highly impregnated with bitumen and with iron pyrites (sulphuret of iron); these by reacting on each other produce a decomposition of the rock, and an approach to the formation of the salt; and from these is prepared in various ways the alum of commerce. In the slaty stratum there are, among other elements, sulphur, alumina, and iron; and these, by the long-continued action of air and moisture, lead to the formation of sulphate of alumina and sulphate of iron. Heat aids this transformation, and hence there are two modes of treatment—one for the efflorescent, or powdery ore, and one for the stony ore.

Alum slate, or alum shale, is a very abundant source of alum. It occurs in Tennessee, and in New-York in the small lake district. It occurs in the lower secondary rocks, and in the latter district is exposed by the ravines, which have cut their way over and through the strata in the passage to the Lakes; the Falls of Lodi, in Seneca Co., N. Y., is over alum slate, and the rough mineral crystallizes out on the surface of the cascade. Alum shale is a grayish or bluish colored rock, splitting readily, and friable on exposure to the air: it dries or effloresces on the surface, and acquires an astringent taste. The first step in the process is the roasting of the ore. Sometimes the shale contains so much bituminous matter that after being fired it keeps up its own combustion: in most cases it is necessary to add additional fuel, either brushwood or coal: a thin layer of wood is generally spread on the ground, and then above it a layer of slate. This is set fire to, and while burning an additional layer of brushwood and of slate are added, and alternate layers are supplied as those below become roasted: by this process the iron pyrites in the ore is decomposed, the sulphur and the iron are both oxydized—the sulphur being converted into sulphuric acid, and the iron into oxide of iron then unite to form sulphate of iron, or copperas, and any additional sulphuric acid unites with the alumina to form sulphate of alumina. These salts are then removed from the ore by washing it. The ore is put into large flat pans of wood, or masonry, called "steeps," and the water is left upon it for twelve or sixteen hours when it is fresh ore: this process is repeated three times on each batch of ore, diminishing the time of maceration as the process is repeated. The water, which has lain upon a weak slate, is transferred to one containing more saline matters. From these steeps the liquor is pumped into a series of long-arched boilers, so formed as to apply heat. By this means the water is evaporated, and the highly concentrated liquor is then transferred to large coolers, where it remains for a fortnight undisturbed. During this interval crystallization goes on: the liquor contains sulphate of iron and sulphate of alumina, and the former of these separates from the latter by gradually crystallizing out. Sticks are immersed in the liquid in the coolers, and around these sticks large bundles of beautiful green crystals collect, forming the well-known green vitriol or copperas of the shops. When the crystals of copperas have been removed, the remaining liquor is drawn off into an evaporating boiler in order that the sulphate of alumina may go through the same process as the copperas; and after being boiled down to a certain strength, the liquor is drawn off into a cooler. Sulphate of alumina will not crystallize without potash or some other alkali be added, and this substance is therefore added to the cooler, in which, after some days standing, crystals of alum are produced: it is thus a double salt, a sulphate of alumina and a sulphate of potash. This is crude alum, and it is further purified by other processes of boiling, evaporating, and crystallizing.

When the hard or stony ore is used, a preparatory process is necessary. This ore is in appearance midway between slate and stone coal, contains sulphur, iron, and alumina, like the decomposed ore; but these three elements have not yet been combined into the sulphates of iron and alumina: the aid of heat is necessary for this transformation. The ore after being broken into small pieces is built up into long ridges with fuel beneath, and air-holes in different parts, and it is then fired; after which the ore undergoes the same treatment as before described. The copperas is thus always an extra product in the manufacture of alum. It is impure, and is usually roasted at a strong heat; and when washed yields more alum. The red residue after roasting is ground to a fine powder, and when dried is used as a *Venetian red* pigment: by altering the temperature at which it is dried, a *yellow* ochre is obtained instead of a red. In France alum is made from clay, which is first finely ground, and mixed with half its weight of crude sulphate of potash: these are formed into balls five inches in diameter, and calcined in the furnace; they are then transferred to the bottom of the chamber in which sulphuric acid is made, where they swell up, and open on all sides, owing to the acid vapor entering them. They are then lixiviated with water, and crystals of alum are obtained by evaporating the liquid.

Dr. Turner, of England, took out a patent in 1842 for obtaining alum by the decomposition of felspar.

It is occasionally made from the pure materials themselves. The finest pottery clay is calcined in an oven to drive off the water, and the vegetable matter combined with it; it is then placed in a tank sunk in the ground, and to this is added sulphuric acid: the reaction is so powerful that both together soon form a boiling mixture, although no heat be applied. Water is then added, and the whole allowed to settle; the clear liquid (solution of sulphate of alumina) is then pumped up into leaden vessels, where it receives the addition of some sulphate of potash as a means of giving the third ingredient necessary to form crystallized alum. It is, however, not yet pure, or fine in quality, and has to undergo the process of *roaching:* this is meant to imply the production of an alum similar to rock alum, which derives its name from Roccha in Syria, where it was first made. In roaching, steam is brought to act upon the alum so as to dissolve it, and form a strong solution. This is done in a leaden vessel, from which the solution is transferred to large cylindrical crystallizing vessels, where it attains the final state in which it is sent into market.

There is a peculiarity about alum which has led to an entirely new branch of manufacture. Alum is not necessarily a sulphate of alumina and potash; in some instances soda, and in others ammonia, has been used, instead of potash, forming soda alum and ammonia alum. These bodies merely aid by facilitating the crystallization of the sulphate of alumina, but they are of no practical service in the chief purpose to which alum is applied in the arts: the sulphate of alumina is the real working agent, and if this could be obtained in a pure and solid state the alkali would in most cases be unnecessary. It happens that the iron contained in small quantity in the clay, and which would injure the alum if allowed to remain, is with difficulty removed except by crystallization; recently, however, a new process for forming a "patent alum" has been adopted. In making this alum sulphuric acid and porcelain clay are used as before, but the clay is used in greater proportion, so as to form a mortar, which is placed in a heated trough, where it is converted into a dry earth: thence it is removed to tanks, where water dissolves it; and while here the composition is acted upon by an agent intended to remove the iron. This is yellow prussiate of potash, which by uniting with the iron forms Prussian blue; this latter is allowed to subside, the clear liquor decanted off and boiled down to a solid residue, which is formed into cakes two inches thick, and it is sent into the market. It is now an opaque earthy solid, differing from common alum by containing no potash. The Prussian blue is collected, and is so treated as to be restored to the form which it had previous to use, and is thus ready for a fresh quantity of crude sulphate of alumina.

Crystallized alum is composed of

1 atom of sulphate of alumina,
1 atom of sulphate of potash,
24 atoms of water

Or by weight—

Alumina	10·82
Potash	9·94
Sulphuric acid	33·77
Water	45·47
	100·00

The ammonia alum contains more water.

ALUMINA. An earth of very common occurrence in primitive and secondary rocks: in the minerals felspar and mica it is associated with silica, iron, and potash; from the decomposition of these clay is formed. It is the oxide of a metal named aluminum, and it consists of 2 equivalents of that metal united to 3 equivalents of oxygen. It can be obtained pure by adding ammonia to a solution of potash alum, washing the precipitate with warm water, and drying it:

it is then hydrated, or united with water, from which it may be freed by exposure to a red heat in a crucible; it is then a clear white powder, soft to the touch, adhesive to the tongue, and insoluble in acids. Its density varies from 2 to 4, acquiring the latter gravity after being burned; when mixed with a small quantity of water, it becomes doughy and plastic: if dried in this state in the air, and then heated, it cracks and shrinks from loss of water. This property is communicated to common clays, which cracks in great droughts, and to modelling clays: Wedgewood made use of it as a measure of heat in his pyrometer, which is now obsolete. Alumina has a great affinity for coloring principles and organic compounds, and its use in dyeing and calico-printing depends on its affinity for these substances and for woody fibre: from its double affinity it seizes upon the coloring matter and upon the tissue of the stuff, and brings them both into contact, and holds them together. It is on this account the basis of *mordants*. When ligneous fibre is not present, and alumina be added to a coloring matter of vegetable or animal origin, it unites with the latter, and carries it down to the bottom of the vessel, leaving the liquor colorless. Colors so prepared are called a *lake*. Alumina freshly made is soluble in acids, and acts as a base to them; with potash, and a few other bases, it unites, and acts as an acid. When moistened with nitrate of cobalt, and exposed to a red heat, it affords a fine blue color, by which it may be readily detected in small quantity. Alumina occurs native and pure in the sapphire, oriental ruby, topaz, and chrysolite. Gibbsite and diaspore contain water united with the alumina: corundrum and emery are less pure varieties, where the alumina is mixed with a little silica and oxide of iron.

AMADOU. A fungus (boletus igniarius), which grows on the cherry, ash, and other trees, prepared by the Germans into tinder for striking lights with. It is gathered in Autumn, and is cut and beaten until it can be readily torn by the finger. In this state it is valuable as a styptic: by steeping with nitre it forms the tinder. Puff-balls are frequently used as a substitute for amadou.

AMALGAM. The union of mercury or quicksilver with other metals. Many of these crystallize definitely, and may be separated from the excess of mercury with which they are surrounded. They are mostly brittle and soft. Tin and mercury unite by mere rubbing; it has a high reflecting surface, and is used as the back of looking-glasses. Amalgam for the electrical machine is made of mercury 4 parts, zinc 2 parts, and 1 part tin. These when melted and rubbed up with a little lard are fit for use.

AMALGAMATION. The mode by which silver ores may be reduced, mercury being used in the process. The separation of gold from sand and impurities by mercury is an amalgamation.

AMBER. A fossil, vegetable, solid, resin, of various tints of yellow: it is hard and transparent, when polished, a little heavier than water, has a resinous taste, and an odor resembling turpentine: it burns readily, giving off a white, pungent, aromatic smelling vapor. By friction it becomes highly charged with negative electricity, and from this property being first observed in this mineral, called by the ancients *electron*, it received the name electricity. According to Goppert and others, amber is the indurated resin of various fossil trees of the family coniferæ. It is found in the same condition in all latitudes, lying in nodules or masses, disseminated in the sand or fragments of lignite (brown coal) of the plastic clay at the junction of the lower tertiary with the upper secondary bed (chalk): the size varies from that of a nut to masses weighing several pounds. It is sometimes found containing insects —a proof of its once being in a soft or semi-fluid condition. Pictet has numbered 800 fossil species of insects occurring in it. The feather of a bird and a little of the hair of the bat have been found imbedded, with one or two molluscous shells. These species are those which could only have inhabited tropical climates. Copal resembles amber, and common copal inclosing insects has been often fraudulently sold for amber. It occurs in Pomerania, and on the other shores of the Baltic, thrown up on the sand after storms. It is also found in the beds of streams. Pits are occasionally sunk above 100 feet down in the sand, and the amber sought for by a true mining operation. It is found in Sicily associated with bitumen in beds of clay and marl; also in Poland, Saxony, Siberia, and Greenland. The finer kinds are used for ornament, as ear-rings, bracelets, necklaces, &c.; and the coarse kind in medicine and the arts. Amber dissolved in drying linseed-oil makes a good durable varnish. With resin, asphaltum, and drying oil, it forms the coachmaker's varnish. Amber furnishes an oil used in perfumery and also succinic acid used in chemistry. (*See* VARNISH.)

AMBERGRIS. A substance used in perfumery. It is found swimming on the sea, off the coast of Coromandel, Japan, Moluccas, and Madagascar. It is the product of a diseased condition of the liver of the spermaceti whale; its color is gray, white or marbled yellow, and black.

AMIANTHUS. A hornblend mineral. (*See* ASBESTUS.)

AMMONIA. Volatile alkali, first obtained by Priestly in a gaseous form, from sal-ammoniac, whence its name. It is a volatile gas, composed of one equivalent of nitrogen and three equivalents of hydrogen. It is found in the vegetable and animal kingdom. Urine decomposing always contains it: hence the use of that substance in making alum, scouring wool, &c. Ammonia is found united with native oxide of iron, in charcoal, and all soils which are turned up and exposed to the air. Rain water contains traces of ammonia derived from the air, in which it is present in minute quantities.

Ammonia cannot be made by the direct union of its elements: one of these substances must be in the nascent state. The usual mode of manufacturing is to mix sal-ammoniac, or hydro-chlorate of ammonia reduced to powder, with an equal weight of fresh slaked slime; these are to be put into a retort, with just so much water as makes the mass become lumpy; on applying a gentle heat to the retort, the ammonia comes off in large quantities as a gas, and if desired pure, may be collected in vessels over the pneumatic trough. By this process the lime removes the hydro-chloric acid, forms with it chloride of calcium and water, and the ammonia is set free; if received into vessels of water, it dissolves very speedily, water at 50° taking up 670 times its volume of gas, and the density of the solution diminishes as the strength increases. A saturated solution of ammonia contains 32½ per cent. of gas, and has a sp. gr. of ·8750. This is called liquid ammonia, and is the liquor ammoniæ of the pharmacopeia; it is colorless, transparent, very pungent, and has well marked alkaline properties. It weakens by exposure to air or heat, the ammonia flying off rapidly. It blues red litmus, and changes vegetable blues to green: it turns turmeric and vegetable yellows brown, and unites with acids to form a numerous class of salts. Organic bodies which contain nitrogen, in fermenting yield ammonia, and generally at the same time carbonic acid. When hoofs, bones, tendons, horns, &c., are heated in iron cylinders, they are decomposed, and carbonate of ammonia is set free along with an empyreumatic oil: when freed from the latter it is termed *spirit of hartshorn*. The gluten of corn, wheat, and other cerealia, yield ammonia when heated; it is also found in soot, and in great abundance when bituminous coal is heated to redness, as in the manufacture of gas.

ANCHOR. A heavy iron hook of great strength, used to hold on a ship to the ground, and fasten itself in a certain situation by means of a rope. Too much importance cannot be attached to the mechanism and construction of anchors, for upon these depends the safety of the ship, especially on lee shores, where otherwise the vessel may be stranded or wrecked. The earliest anchors were doubtless heavy stones, around which a rope passed, and which, by its weight, retained the vessel in its place. The Chinese use crooked pieces of heavy wood at the present day. The action of the modern anchor is to bite the ground, and from the direction of the strain upon it, the anchor cannot move without ploughing up the ground in which the fluke or hook is sunk. When this unhappily occurs, it arises from the softness of the ground, or the violence of currents and waves. The ship is then said to drag her anchor. When well anchored, the cable will break, or the fluke will be snapped off and left in the soil, rather than loose its hold. Anchors have different names, according to their sizes and the purposes they serve, as sheet, best bower, small bower, spare, stream, and kedge anchor. The largest ships have seven anchors, the smaller, as brigs, cutters, and schooners, only three or four. The manufacture of anchors requires great knowledge of the structure of iron, and skill in manufacturing it.

The shank of an anchor is made long, so that the stock, or cross-piece, near the cable-ring, may have greater power in directing one or other of the arms downwards: where it joins the stock it is square to receive and hold the former securely. In the square part is a hole for receiving the ring for the cable. The arms form an angle of 56° with the shaft, they are rounded for the first half of their length, and the remainder is flattened out and is called the blade. The length of the arm is nearly half the length of the shaft. The stock is generally formed of two oak beams embracing the square, and firmly united by nuts, iron bolts, and hoops; occasionally it is made of wrought iron, and then it passes through a hole in the square.

The weight of anchors for vessels is generally apportioned to the tonnage, the weight of the anchor in hundred weights being one-twentieth the number of tons of burden,—thus a ship of 1000 tons would require a sheet-anchor of 50 cwt. In the English navy 1 cwt. is allowed for every gun; an 80 gun ship will have an anchor of 80 cwt. The weight of an anchor ten feet long, is 11·4 cwt, and if all forms of anchor be the same, the weights would be as the cubes of the lengths: hence the weight of an anchor can be found by multiplying the cube of its length by ·0114. This gives a sufficiently close approximation; but for large anchors this is too small, because the thickness is greater in proportion.

Anchors have been made with only one arm. Mr. Stuard patented one of this kind some years ago. To insure the anchor falling the right way, with the fluke down, the shank was shortened, so that when suspended by the cable, it will cant the most, and when it has hold in the ground, the ship will ride more safely, as a long shank is more likely to be bent, or broken from its hold. The bars which compose the anchor are put together in one length, there is no welding together, and its strength is thus much increased. The great object in anchors is to provide the greatest strength, by preserving such a disposition of the fibres of the metal as shall conduce to this. The crossing or bending of fibres at the junction of the flukes with the shank and with the crown should be avoided, as great strength is required in these parts. In this respect most anchors are defective, for in connecting the shanks with the crown-pieces, the grain of the metal is crossed or curved, so as to strain the fibre and induce a weakness. Mr. Piper, in 1822, proposed new forms and constructions to meet and overcome this objection. Mr. Rodgers, Lieut. R.N., England, in 1846 patented an improved construction of stocks, shanks, arms and palms of anchors, in such a manner, that they will, with the same weight of metal, be stronger in the direction in which the strain comes on them, and have greater holding power than any which have hitherto been used. The form is based on the principle of the wedge, which is a cross-section of the stem or shank, and being of a rectangular form, is better calculated to resist the strain to which that particular part is subjected, than any anchor of the usual form. The stem is reduced at the end next the stock, where the principal strain being tension or twisting, it is better suited to resist than any other. The arm is wedge-shaped, the outer circumference of the arc being broader than the inner, thus disposing of the metal so as to obtain the greatest amount of strength, and at the same time have a greater holding power by the pressure of the soil on the sides of the arms. The palms are made with the bevelled sides in front instead of the back, as hitherto: this also produces a greater holding power, for in dragging the anchor he found, from actual experiment, that the soil fills up behind the palm, and prevents the water entering the rut. In applying one part of this invention to anchors already made, a piece of iron is welded on to the front of the arm to form the palm, the parts projecting beyond the arm being bent back, and forming the bevelled surfaces, which will have a similar effect to that already described when the palms are forged out in the solid.

Anchors are sometimes liable to be disturbed by *ground ice* being formed at the bottom of the water; this occurs when the temperature is lower and the water not deep. Anchors to which buoys have been attached, have been raised in the Baltic sea owing to this cause, and stones, from 3 to 6 lbs., have been floated to the surface by the lifting power of the ice. Under such circumstances, the slow formation of ice round an anchor tends to give it a lifting power and make it relatively lighter, so that upon a slight moving force applied to it, or even upon a further formation of ice, the anchor gradually rises out of the soil.

ANCHOVY. Small soft-finned fishes of the herring species, inhabiting the tropical seas of this continent and India. They are caught in the Mediterranean sea in abundance from May to July, the fish then leaving the Atlantic to deposit their spawn on these shores. The fishing is carried on by night, the anchovies being attracted by the charcoal fires which are burned in the stern of the boats. The head, gills, and entrails are removed, and the bodies salted and packed in small casks, from 5 to 25 lbs. weight, and if the air have been excluded, they will keep good for any length of time.

ANEMOMETER. A measure of the velocity or force of wind. To ascertain this force is sometimes of considerable moment to mechanical science. Cronne, in the 17th century, and Wolfins and others in later times, have invented instruments for this purpose with but partial success; in them the velocity of the wind was measured by its mechanical force, as by the compression of a spiral spring, or by the elevation of a weight round a centre, acting at the arm of a variable lever. Leslie's anemometer depended on the principle that a stream of air had a cooling power in proportion to its velocity. Lind's anemometer raises a column of fluid above the general level of its surface. It consists of two tubes, 9 inches long and ⅛ inch wide, connected together at the bottom by a tube of very narrow bore; a thin metal cap, bent at right angles, is fitted upon one extremity, so that it may receive the current of air in a horizontal direction. The tubes are half filled with water, and a scale on which inches and tenths can be read off, is placed between the tubes. When the wind blows into the cap it depresses the water in the first tube and raises it in the second, so that the distance of the surfaces of the fluid is the length of a column of water equal to the base of the column of fluid. The absolute velocity of the wind is calculated from the height of the column of water, or it may be ascertained from tables made for the purpose.

Dr. Whewel's form of anemometer is one in much use. By means of a vane a windmill-fly is presented to the wind, the fly revolving with more or less velocity, according to the rapidity of the wind. By means of an endless screw and wheel-work attached, the motion of the fly brings a pencil down over a fixed cylinder, tracing a certain path, which may be longer or shorter, as the wind is rapid or slow. The pencil descends only one-twentieth of an inch with 10,000 revolutions of the fly. The surface of the cylinder is whited, and divided into thirty-two equal parts by vertical lines, the spaces corresponding to the points of the compass, so that a mark left by the pencil in these spaces indicates the direction of the wind. The pencil moves in two ways: downwards to indicate the velocity, and laterally to indicate its direction. The cylinder is fixed, the vane and wheel-work being on a turning-table to which the pencil is connected, and these are obedient to the wind. The friction in this machine is very great, arising from the wheel-work and the pencil; in the former it chiefly resides, because a rapid motion has to be converted into a descending slow one.

Osler's anemometer traces the direction of the wind and its pressure upon a given space, with the fall of rain, on a register divided into twenty-four spaces, corresponding to the hours of the day. A clean paper register is placed on the board every day, which is carried on by clock-work behind three pencils or indices. The board moves on friction rollers, and is kept constantly and hourly moving, so that a continued record or trace of the direction and pressure of the wind, together with the amount of rain, is left on the paper, and it indicates the direction, the duration, and the force of the wind.

Mr. Philipps, in a paper read to the British Association, has reproduced Leslie's principle in his "Anemoscope," in which he proposes to measure the velocity of air by the rapidity of evaporation, and the cold produced thereby. When the bulb of a thermometer, covered with cotton wool, is immersed in water and exposed to the air, the evaporation is known to produce a given amount of diminution of temperature, and when the thermometer is moved through the air, the rapidity of evaporation is increased. By repeated trials in tranquil air, and when the thermometer was in motion, he was enabled to ascertain the increased rates of cooling by various degrees of speed, and on the other hand to tell the amount of speed by the rapidity of cooling. He tested the instrument on the South-Western Railway (England), and when the carriages were at the velocity of thirty-six miles an hour, his new anemometer indicated correctly the amount of velocity in its being held two feet from the carriage.

Dr. Robinson, of Armagh, Ireland, in 1846 constructed and worked an anemometer, the connection of the motion of which with the velocity is subject to little variation, and is of easy determination. It consists of two or three arms attached to a spindle, carrying at their extremities hollow hemispheres of tin and copper, with the hollows of the hemispheres all turned in the one direction. The force of the wind exerted on the concave surface being four times greater than on the convex, the spindle is made to turn in the same direction, whatever way the wind blows. Attached to the spindle are the count-wheels of a gasometer, and the velocity thus determined is exactly the one-third of that of the wind. So trivial is the friction in this machine compared with its power, that its motion was quite perceptible in breezes which were too gentle to disturb the leaves on neighboring poplar trees. It is the most correct anemometer as yet invented.

ANEROID. A new patent French barometer. The principle of its construction is this: a cylinder of copper, with a very thin and corrugated end, was partially exhausted and hermetically sealed, the effect of the varying pressure of the atmosphere on the thin end was magnified by a system of levers, so as to affect the index of a dial very little larger than that of a watch. The indications of this instrument have been tested, by placing it under the receiver of an air-pump, and observing its march in comparison with the indications of the long gauge, and they were found to agree to less than one-hundredth of an inch. The construction of this barometer consists in "the application of thin sheets of metal, glass, India-rubber, or other flexible material, to certain apparatus employed for measuring the pressure and elasticity of the air and other fluids in such a manner as to form a buffer, or cushion, susceptible of the slightest variation of pressure of the atmosphere or fluid with which it is in contact, and indicating the amount of pressure by the amount of depression." A detailed description of this barometer is given in the London Mechanics' Magazine, No. 1307.

ANIME. An exudation of the courbaril tree of Cayenne and the Equatorial districts of South America. It is exported in lumps of different sizes, often including perfect insects, and parts of other organic remains of living species: hence it has derived its name as being animated. It contains a little volatile oil, is resinous, of a light brown color, brittle, and transparent. Alcohol and essential oil of caoutchouc mixed, dissolve animè into a jelly, but not perfectly.

ANNEALING, or NEALING. A process applied in the manufacture of glass and some metals, to prevent the particles arranging themselves in that condition which produces a brittle quality. When a glass vessel is allowed to cool immediately after being blown, it will often bear to be struck violently on the outside with a stone or hammer without injury; but if a small piece of glass be gently dropped into it, flies to pieces either immediately or after a few minutes—a slight scratch is often sufficient to break it. This curious phenomenon of unannealed glass is illustrated in the *Bologna phial*, and Prince Rupert's drops. The former will bear a pistol bullet to fall on it from a height of two feet without harm; but if a grain of sand drop into it, it flies to pieces. These phials lose this property by age. Rupert's drops are glass melted off a rod, and allowed to drop into cold water: many will burst in the water, but those which escape show the unannealed property remarkably. They may be struck with a hammer on the bulb-end unharmed; but snapping off an extremity of the capillary tail, makes the whole drop fly to pieces so small as to be fine dust. If the drops and the phials be heated and allowed to cool slowly, they lose this property. By sudden cooling, the particles of glass have not time to arrange themselves in that form which constitutes stable equilibrium, and hence on the slightest disturbance at favorable points, an attempt is made at re-arrangement. Glass forms one of the few exceptions to the law that bodies contract in size in passing from the fluid to the solid form. When it is allowed to cool slowly its molecules arrange themselves in a fibrous form so that freedom of motion or elasticity of the whole mass results; and the substance can propagate vibrations from one extremity to the other. But when melted glass is suddenly cooled, the solidification of the surface occurs so fast that the particles of the interior are enclosed before they have had time to arrange themselves in this elastic condition. The cohesion of the particles is but slight, a partial force overturns it. Drinking glasses which are unannealed and happen to be thick, are easily broken on that account when they are thrown into vibrations. While annealing, the glass is kept at a condition nearly fluid for several hours, by which means the interior particles can expand and crystallize regularly. Mr. Pellat has proved that this arrangement of particles does take place: he found that two tubes of equal size (forty inches long), the one which was annealed contracted one-sixteenth of an inch more than that which was cooled in the air. Glasses which are exposed to rapid transitions of temperature, may be annealed better than is done in the glass-house, by placing them in a vessel of cold water and raising it to the boiling point, and keeping it so for some hours. Lamp-shades ought to be heated always in this way.

When metals have been hammered out very much they become brittle, and they will crack if it be carried much farther: their malleability is restored by the workman annealing them, or heating them red hot. The annealing seems to remove the closeness of the proximity of the particles of metal which the hammer-hardening had produced. In the manufacture of some articles of steel after they have been hammered into shape, they are annealed to allow of their being cut by the scissors or file. In wire drawing, in the rolling and flattening of vessels, it is necessary to anneal occasionally, otherwise the metal would become too hard and would not extend. Iron and steel are occasionally annealed in the open fire, and left to cool gradually by simple removal. This oxydizes the surfaces and destroys the steeling.

Soft metals, such as tin and lead, are annealed by being dipped into hot water.

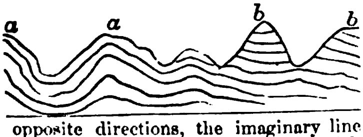
ANNOTTO. The red coloring matter of the Bixa Orellana, a plant of the West India islands, where it is cultivated on the banks of rivers. As obtained in commerce, it is a dry and hard paste, made from the seeds into a pulp, which, after having fermented, is rolled into pieces of two or three pounds' weight: it is imported under the names annotto, Roucou, or Orleans, and is used occasionally as an orange dye and for coloring cheese. It imparts little color to water, but dissolves in alcohol and alkaline solutions: its color is not materially altered by acids or alkalies.

ANTHRACITE. (Gr. ἀνθραξ, *charcoal.*) Mineral carbon. A difficultly combustible species of coal.

ANTIAR. (A. UPAS.) A Javanese poison.

ANTI-ATTRITION. A compound applied to machinery to prevent the effects of friction. It frequently consists of a mixture of plumbago with some greasy material.

ANTICLINAL AXIS. (Gr. ἀντί *against*, and κλινειν, *to incline.*) If a range of hills or a valley be composed of strata which, on the two sides, dip in opposite directions, the imaginary line that lies between them, towards which the strata on each side rise, is called the anticlinal axis. In a row of houses with steep roofs facing the south, the slates represent inclined strata dipping north and south, and the ridge is an east and west anticlinal axis (Lyell). In the annexed diagram, *a a* are the anticlinal, *b b* the synclinal lines.



ANTIMONIC ACID. The peroxide of antimony. (*See* ANTIMONY.)

ANTIMONY. A brittle metal of a silver white color; specific gravity, 6·7. Fuses at 810°, or just at a red heat. The principal properties of this metal were first described in the "Currus Triumphalis Antimonii" of Basil Valentine, published towards the end of the 18th century. When heated in an open vessel, it gradually combines with oxygen, and evaporates in a white vapor. There are three oxides of antimony. The protoxide consists of 65 antimony + 12 oxygen; it is a grayish white powder eminently purgative, sudorific, and emetic; and as such, of much importance in medicine. It is the active base of emetic tartar and of James's powder. The other oxides of antimony, from combining with certain bases, have been called antimonious and antimonic acid; they consist respectively of 65 antimony + 16 oxygen, and 65 + 20. The combination of chlorine and antimony was known to the old chemists under the name of *butter of antimony.* The principal ore of antimony is the *sulphuret:* it is met with in commerce, melted into conical ingots, under the name of crude antimony. It is of a bluish gray color, metallic lustre, and a striated texture; specific gravity 4·62; it is much more easily fusible than the pure metal. Antimony forms brittle alloys with some of the most malleable metals: when gold is alloyed with a two-hundredth part of antimony, the compound is brittle; and even the fumes of antimony in the vicinity of melted gold are sufficient to render it brittle. Alloyed with lead in the proportion of 1 to 16, and a small addition of copper, it forms the metal used for printer's types: with lead only, a white and rather brittle compound is formed, used for the plates upon which music is engraved. With iron it forms a hard whitish alloy, formerly called *martial regulus:* 12 parts of tin and 1 of antimony form hard pewter. The white metal spoons and teapots are formed of an alloy of 100 tin, 8 antimony, 2 bismuth, and 2 copper.

Antimony is the stimmi, or stibium, of the old chemists. The protoxide of antimony has been used in France and England lately as a white paint in substitution for carbonate of lead.

APATITE. Native phosphate of lime. (*See* PHOSPHORITE.)

APHRITE. A soft friable carbonate of lime.

AQUA. Water. A word of uncertain derivation.

AQUA MARINE. Beryl.

AQUA FORTIS. Nitric acid.

AQUA REGIA. A mixture of nitric and muriatic acids, so called from its power of dissolving the noble metals, gold and platinum.

AQUATINT. (Lat. aqua, *water*, tinta, *dyed.*) In engraving, a species of execution resembling an Indian ink drawing in effect. (*See* ENGRAVING.)

AQUEDUCT. (Lat. aqua, *water*, and ductus, *a conduit.*) A conduit or channel for conveying water from one place to another; more particularly applied to structures erected for the purpose of conveying the water of distant springs across valleys, for the supply of large cities.

The largest and most magnificent aqueducts, with the existence of which we are acquainted, were the work of the Romans; and the ruins of several of them, both in Italy and other countries of Europe, remain to the present time monuments of the power and industry of that enterprising people. The aqueduct of Appius Claudius was the most ancient, and constructed in the 442d year of Rome. It conveyed the Aqua Appia to the city, from a distance of between 7 and 8 miles, by a deep subterranean channel of more than 11 miles in length. The aqueduct of Quintus Martius was a more extraordinary structure. It commenced at a spring 33 miles distant from Rome, made a circuit of three miles, and afterwards, forming a vault of 16 feet diameter, it ran 38 miles, along a series of arcades at an elevation of 70 English feet. It was formed of three distinct channels, placed one above the other, conveying water from three different sources. In the uppermost flowed the Aqua Julia; in the second, the Aqua Tepula; and in the undermost, the Aqua Martia. The Aqua Virginia, constructed by Agrippa, passed through a tunnel of 800 paces in length. The Aqua Claudia, begun by Nero, and finished by Claudius, conveyed the water from a distance of 38 miles. This aqueduct formed a subterraneous stream of 30 miles in length, and was supported on arcades through the extent of 7 miles; and such was the solidity of its construction, that it continues to supply the modern city with water to the present day. The waters of the river Anio were also conducted to Rome by two different channels; the first was carried through an extent of 43 miles, and the latter through upwards of 63 miles, of which 6¼ miles formed one continued series of arches, many of them upwards of 100 feet in height. Nine great aqueducts existed at Rome at the commencement of the reign of Nerva. Five others were constructed by that emperor, under the superintendence of Julius Frontinus; and it appears that at a later period the number amounted to twenty. The supply of water furnished by these different works was enormous. "According to the enumeration of Frontinus, the nine earlier aqueducts delivered every day 14,018 quinaria. This corresponds to 27,743,100 cubic feet. We may therefore extend the supply, when all the aqueducts were in action, to the enormous quantity of 50,000,000 cubic feet of water. Reckoning the population of ancient Rome at a million, which it probably never exceeded, this would furnish no less than 50 cubic feet for the daily consumption of each inhabitant."

The remains of some Roman aqueducts in other parts of Europe give evidence of the existence of works on a still more magnificent scale than those of Rome. Of these the aqueduct of Metz was one of the most remarkable. A number of its arcades still remain. It extended across the Moselle, a river of very considerable breadth at this place, and conveyed the water of the Gorse to the city of Metz. The water was received in a reservoir, whence it was conducted by subterraneous canals, formed of hewn stone, and so spacious that a man might walk in them upright. The arches appear to have been 50 in number, and 50 feet high at the deepest part. Some of the middle ones have been swept away by the descent of ice down the river; those at the extremities still remain entire.

The aqueduct of Segovia, in Spain, is in a still more perfect state than that of Metz. About 150 of its arcades remain, all formed of large stones without cement. There are two rows of arcades, the one above the other, and the height of the edifice is about 100 feet, passing over the greater part of the houses of the city.

Aqueducts have been constructed in modern times, particularly in France, which rival those of the ancient Romans.

One of the most remarkable was constructed by Louis XIV., for conveying the waters of the river Eure to Versailles. It extends about 4400 feet in length, or nearly seven-eighths of a mile, and is upwards of 200 feet in height. It contains 242 arcades, each divided into three rows, forming in all 726 arches of 50 feet span. The introduction of cast-iron pipes, which has only taken place within the last century, has superseded the use of such expensive structures. (*See* CROTON AQUEDUCT.)

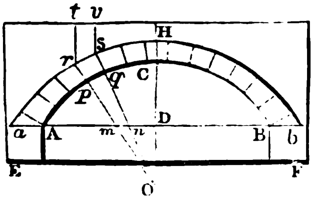
AQUEOUS SOIL. Agr. and Hort. Soil naturally abounding in water, the fluid being supplied by springs in the subsoil.

AQUETTA. (Ital. *little water.*) A celebrated poison used by the Romans under the pontificate of Alexander VII. It was probably a preparation of arsenic, and was also known under the name of *aqua Toffana*, from a woman of the name of Toffana, who prepared it at Naples.

ARAR. The Barbary name of *Thuja articulata*, the tree whose wood is chiefly used by the Mahometans of Africa for the construction of their mosques, and whose resin is the sandarach of commerce.

ARBOR. The spindle or axis which communicates motion to the other parts of a machine.

ARCH. (Lat. arcus, *a bow.*) In building, a structure of stones or bricks, or distinct blocks of any hard material, disposed in a bow-like form, and supporting one another by their mutual pressure. In describing arches some technical terms are made use of, which it will be convenient to define. The arch itself is formed by the vouissoirs, or stones cut into the shape of a truncated wedge, the uppermost of which at C is called the key-stone. The seams or planes, in which two adjacent voussoirs are united, are called the joints; the solid masonry, A E and B F, against which the extremities of the arch abut or rest, are called the abutments: and the line from which the arch springs at A *a* B *b*, the impost. The lower line of the arch-stones, A C B, is the intrados or soffit; the upper line, the extrados or back. The beginning of the arch is called the spring of the arch; the middle, the crown; the parts between the spring and the crown, the haunches. The distance A B between the upper extremities of the piers, or the springing lines, is called the span, and C D is the height of the arch.



There is considerable difficulty in determining the form which an arch ought to have, in order that its strength may be the greatest possible, when it sustains a load in addition to its own weight; in fact, the determination cannot be accurately made, unless we know not only the weight of the materials the arch has to support, but also the manner in which the pressure is connected; that is to say, unless we know the amount and direction of the pressure on every point of the arch. Supposing, however, that the arch has to sustain only its own weight, and supposing further, that the friction of the arch-stones is reduced to nothing, a relation between the curve and the weight of the voussoirs may be found by comparing the pressures which are exerted on the different joints. Thus the pressure on any joint, *s q* for example, arises from the weight of that portion of the arch which is between *s q* and the summit C H. Now, the portion of the arch C *q s* H is sustained by three forces: the pressure on the joint *s q*, the pressure on C H, and its own weight. Let *s q* be prolonged till it meets C D in O, and let *n* be its intersection with A B. It is a theorem in statics, that when a body is held in equilibrium by three forces balancing each other, these forces are proportional to the three sides of a triangle formed by lines respectively perpendicular to the directions of the forces. The three forces sustaining C *q s* H are, therefore, proportional to the sides of the triangle O D *n*; for the pressure on *s q* acts in the direction perpendicular to *s q* or O *n*; the pressure on C H is perpendicular to D O, and *n* D is perpendicular to the direction of gravity. The pressure on *s q* is, therefore, to the pressure on C H as *n* D to D O. In like manner, the voussoir *p r q s* being so shaped that *r p*, when produced, meets O H in the point O; the pressure on the joint *r p* is to that on C H, as *m* D to D O. Hence, the pressure on *s q* is to the pressure on *r p* as D *n* to D *m*. We are thus led to infer that the voussoirs ought to increase in length, from the key-stone to the piers, proportionally to the lines D *n*, D *m*, &c.; for in this case, the surfaces of the joints being increased in proportion to the pressure they sustain, the pressure on every point of the arch will be equal. It will also be observed that the angle *n* O D is equal to the angle made by a tangent to the curve at *q*, and the horizontal line parallel to A B; the angle *m* O D equal to that made by the tangent at *p* and the horizontal line; and the radius D O remaining constant, D *n* is the tangent of the point of these angles, and D *m* of the second; hence the pressures on the successive joints are proportional to the differences of the tangents of the arches reckoned from the crown. From this property, when the intrados is a circle given in position, and the depth of the key-stone is given, the curve of the extrados may be found. When the weights of the voussoirs are all equal, the arch of equilibration is a catenarian curve, or a curve having the form which a flexible chain of uniform thickness would assume if hanging freely, the extremities being suspended from fixed points.

Such is the form which theory shows to be the best adapted to give strength to an arch, on the supposition that there is no superincumbent pressure. But it seldom if ever happens that this is the case, and therefore it is entirely unnecessary, in the actual construction of an arch, to adhere closely to the form determined on the above supposition. Indeed, on account of the friction of the materials and the adhesion of the cement, the form of the arch, within certain limits, is quite immaterial, for the deviation from the form of equilibration must be very considerable before any danger can arise from the slipping of the arch-stones. The Roman arches are almost semi-circles, yet they have lasted many centuries. The arch is not found in an Egyptian building nor in the earlier Greek. The Romans understood the advantage of the arch from an early period. The cloaca maxima is of the age of the Tarquins. The Etruscans originated the arched dome, and the Romans first applied the arch to bridges and aqueducts. The pointed arch was introduced in the middle ages by the associated architects, who have left extant the noblest piles of architecture, and in which the arch is multiplied and combined in all possible ways. (*See* BRIDGE.)

ARCHIL. *Orchil. Cudbear.* A violet dye obtained from many species of lichen, chiefly the ***Rocella tinctoria, fuciformis***, which grow in large quantities in the Canary Islands. Archil is chiefly used to improve the dye of other colors, and to give richness and brilliancy to them. The lichens grow on rocks near the sea; they are collected and fermented with ammoniacal liquor, which brings out the color; the mass is then pressed out, and made into a paste with chalk and plaster of Paris. It is then archil. The coloring matter is due to the chemical principle *orcine*. In silk-dyeing archil produces the lilac color; it economises the use of indigo on woollen cloth. It also stains marble violet.

AREOMETER. An instrument for measuring the density or specific gravity of liquids.

ARGAND. (*See* LAMPS.)

ARGIL. Argillaceous earth. A name applied to the earth of clay, termed alumina, from its being found so pure in alum.

ARGOL. The tartar of wine.

ARICINA. An alkaloid discovered by Pelletier in a species of cinchona.

ARRACK. A spirituous liquor obtained by distilling fermented rice or the juice of the cocoa-nut.

ARROW ROOT. The commercial name of the starch obtained by washing the grated root of the maranta arundinacea, which it yields to the amount of twenty-five to thirty per cent. It is sometimes adulterated with potato starch, and the fraud is not easily detected; it, however, gives a disagreeable flavor and smell, like that of the raw potato, and forms a less firm jelly with hot water that when the arrow root is genuine.

The roots when one year old are dug and washed; they are grated, and the pulpy matter agitated with water. The fibres are collected by hand and removed, and the milky liquor strained through a sieve and left to settle. The white pasty mass is the arrow root, which is perhaps again washed, then dried, and packed for exportation. The arrow root of Bermuda is considered the finest. *Tous le mois*, or starch, is obtained from the roots of canna coccinea; Otaheite arrow root from the tacca pinnatifida. The East Indian from a *curcuma*, and the Portland arrow root from *arum maculatum* are occasionally used as substitutes. The grains of arrow root are in the form of small globes or spheres when viewed by the microscope.

ARSENIC. A very soft, brittle, and eminently poisonous metal, of a steel gray color: its sp. gr. 5·7. It volatilizes, exhaling a strong odor of garlic, before it fuses, at a temperature of 365° F., and is easily inflammable. It combines with oxygen in two proportions; and as both compounds are sour, and form salts with bases, they have been termed arsenious and arsenic acids: the former is composed of 38 arsenic and 12 oxygen, and the latter of 38 arsenic and 20 oxygen. Arsenious acid is more commonly known under the name of *white arsenic*, and is the usual state in which this poison occurs in commerce; it is obtained during the extraction of several of the metals from their ores, and is a white, brittle, semi-transparent substance, having little taste, but is virulently poisonous. Its sp. gr. is 8·7. It forms a dull white powder, and it is in this form that it is usually sold. When heated in the flame of a candle, it rises in the form of a white poisonous vapor, and exhales, in consequence of its partial reduction, a strong garlicky smell: 1000 parts of cold water dissolve about 2¼ of white arsenic; but when the water is boiled with the arsenic, 1000 parts take up between 77 and 78; and this solution, after standing a few days, deposits rather more than half of the white arsenic, in the form of small crystals, retaining about 30 grains in permanent solution. White arsenic dissolves in the alkalies, and combines with the metallic oxides, forming a class of salts called *arsenites:* they are all poisonous. Of these the arsenite of potash is used in medicine, under the name of Fowler's mineral solution: it is employed in very small doses in the cure of agues, and is an effective remedy, but requires much care in its administration.

When white arsenic is taken as a poison,—that is, in large doses, it produces violent spasmodic pains of the stomach and bowels, attended by a sense of heat, and constriction in the mouth and throat; an increased flow of saliva, tightness about the head, itching of the face and neck, and nausea. These symptoms are succeeded by vomiting and purging and excruciating pains; the pulse at first full, hard, and frequent, sinks and becomes irregularly feeble, and clamminess of the skin, cold sweats, purple spots, and convulsions, precede death; or if the patient escape this catastrophe, it often happens that hectic fever, paralysis, and mental and bodily debility, attend him for the remainder of his days. It is often said that the bodies of persons poisoned by arsenic are very prone to putrefaction; but this does not appear to be always the case. After death the stomach and bowels are usually found inflamed, but often only slightly so; and it appears from Sir B. Brodie's observations, that this poison kills by some peculiar action upon the heart and nervous system. The treatment of persons thus poisoned consists in promoting the vomoting by an emetic, composed of a solution of 20 grains of sulphate of zinc in two ounces of water, aided by copious draughts of warm barley-water or gruel; but the most effective means of getting rid of the arsenic, is by the use of the stomach-pump, which, when immediately resorted to, has often saved the patient. The after-treatment requires much circumspection.

The only ready means of ascertaining the presence of white arsenic is by heating the suspected substance upon a red-hot coal, or in the flame of a candle or spirit lamp, when it will exhale the peculiar arsenical odor resembling that of garlic; but the treatment of persons poisoned by arsenic, and its detection in doubtful cases, must be left to the medical man and the chemist. It is impossible too strongly to represent the evil which results from the unfettered sale of arsenic, and from the unwarrantable use of it as a poison for rats, and as a veterinary remedy, for it is thus that it finds its way into culinary vessels, gets accidentally mixed with articles of food, and that bottles which have contained it are used for beer, wine, vinegar, or medicine: its sale should be rigidly prohibited.

This metal occurs native in the state of white oxide (arsenious acid); also with sulphur, known as yellow and red arsenic. It is associated with a great many metallic ores, but chiefly with cobalt in Silesia, in Europe. It is separated from that metal by roasting, and the arsenic is obtained as white oxide. Arsenic enters into the composition of flint glass, the body of which it whitens and purifies: it is apt, however, to make the glass milky. It is used in candle-making, to remove the crystalline tendency of stearine. It is also used to destroy rats and vermin. It has a remarkable tendency to preserve the parts of the animal body it is brought into contact with, and hence it has been used in the stuffing of birds and the preservation of other objects of natural history. To make an appropriate preparation Dumas gives the following recipe:

White soap and arsenious acid, of each

100 parts; carbonate of potash, 30 parts; camphor, 15 parts; quicklime, 12 parts. The potash, soap, and lime, are melted together; then the arsenic is added. The camphor is dissolved in alcohol, and added in when the mass is cold. Some of this soap mixed with water is laid on with a brush. Arsenic alloyed with metals makes them more brittle and fusible: with copper it forms *white tombac*.

Arsenic acid is more soluble and sour, but equally poisonous with the arsenious acid. Its salts are called *arseniates*, and the arseniate of potash obtained by deflagrating a mixture of white arsenic and nitrate of potash is occasionally used in medicine: it is the active ingredient in the tasteless ague drop. It is also used in calico-printing as a resist paste laid on by blocks to prevent the mordant acting on the cloth in those places.

ARTESIAN FOUNTAINS, or ARTESIAN WELLS. (Fr. Puits Artésiens.) Vertical perforations of the exterior crust of the earth, of small diameter, and frequently of great depth, through which subterraneous water arises to the surface, often forming abundant and elevated jets. The name Artesian is derived from Artois, a province of France, where especial attention has been given to this means of obtaining water; but it appears, from sufficient historical evidence, that wells of this kind were perfectly well known to the ancients. Niebuhr cites a passage from Olympiadorus, who flourished at Alexandria about the middle of the sixth century, in which it is stated that when wells are dug in the Oasis to the depth of two hundred, three hundred, or sometimes five hundred yards, rivers of water gush out from their orifices, of which the agriculturists take advantage to irrigate their fields. The oldest Artesian well known to exist in France is in the ancient convent of the Chartreux, at Lillers in Artois. It is said to have been made in 1126. Others exist at Stuttgart, of great antiquity, though their dates cannot be fixed with precision. The inhabitants of the great desert of Sahara appear also to have been long acquainted with this mode of obtaining water, and the Chinese are said (but the truth of the statement is questionable) to have practised it for thousands of years.

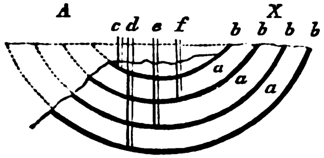
Various conjectures have been made as to the source of the water which comes from the Artesian wells. It was long believed that the water of the sea must necessarily penetrate by way of infiltration into the interior of the continents, and at length form large bodies of subterraneous waters, which, excepting for capillary influences, would not rise above the general level of the ocean. Another opinion, maintained by Aristotle, Seneca, Cardan, and even Descartes, was, that the subterraneous water, from which the sources of rivers and springs are supplied, is the product of the condensation of aqueous vapors ascending from the interior parts of the earth in consequence of the central heat. But these hypotheses are founded on mere conjecture, unsupported by the slightest evidence, and consequently merit no attention. The simplest and most natural explanation is, that the water of ordinary wells, of Artesian fountains and rivers, is supplied by the rain which falls on the surface at a higher elevation, and which penetrates through the pores and fissures of the ground till it meets with some impermeable stratum, or is collected in subterranean reservoirs. It has been objected that springs are sometimes situated on or near the summits of mountains, which could not be supplied in this way; but on an attentive examination of all the circumstances—that is to say, on measuring accurately the extent of surface at a greater elevation than the spring, and comparing it with the quantity of rain that falls annually in the same climate, it has been found, in every instance, that the aqueous deposition from the atmosphere greatly exceeds the supply from the spring. It is computed that not more than a third part of the rain which falls in the valley of the Seine is conveyed to the sea by the river; the remaining two-thirds support vegetation, supply fountains and springs, or are returned to the atmosphere by evaporation. The immense bodies of water which some continental rivers roll towards the ocean are but a small part of the rain which falls in the surrounding countries.

The average fall of rain in these latitudes is about 40 inches of rain, or about 3,500 tons of water deposited in the course of the year on every acre. In sandy districts this rain-water penetrates like as through a sieve. In mines sunk in limestone rocks the water increases in the galleries very remarkably after a fall of rain.

Assuming, then, that the subterraneous water is supplied from atmospherical deposition, it remains to be explained how it arrives at the situation it occupies in the interior of the earth, and by what forces it is raised from great depths to the surface.

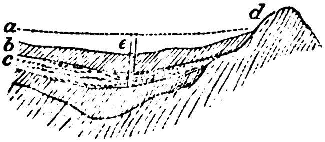
All persons who have paid the slightest attention to geology are aware that in stratified countries (and it is in such only that Artesian wells exist) different beds of rocks are superposed on one another, and ranged in a certain constant order. The strata sometimes follow a horizontal direction for a considerable extent of country; at other places they are inclined, and even placed perpendicularly to the horizon, having the appearance of having been bent and burst through by the action of a powerful force from beneath. In those cases the edges of the strata are often exposed, especially on the summits and flanks of hills, to the action of the atmosphere.

The following diagram illustrates this: it represents a basin composed of permeable strata (*a a a*) separated by impermeable layers (*b b b*). The water which falls on the edges of *a* on the side *x* will sink down and fill the beds until the water rises on the other side, and has a tendency to run out at A. If tubes be sunk in the middle, as at *c d e f*, the water will flow up these tubes until it attains the level of the beds of clay at *b*; and as the ground at the place of sinking is on a lower level, the water will rise in the tube considerably above the surface, and will be thrown up with great force.



Between the strata are frequently found beds of permeable sand, through which water, coming in contact with them, must necessarily pass, first, through the inclined part by virtue of its specific gravity, and then in the horizontal branches, by virtue of the pressure of the water remaining in the elevated portions of the strata. In this manner the water insinuates itself between the different strata; and hence we may expect that in localities where the tertiary stratification prevails, as many distinct sources of subterraneous water will be met with in penetrating perpendicularly through the surface, as there are distinct layers of a sandy or gravelly nature reposing on impermeable strata. This consequence of the theory is perfectly confirmed by experience. M. Arago mentions, that in digging for coal near St. Nicholas d'Aliermont, a short distance from Dieppe, seven distinct and copious sources of water were found, the respective depths of which were: 1st, between 80 and 100 feet; 2d, 328 feet; 3d, from 570 to 590 feet; 4th, from 690 to 710 feet; 5th, 820 feet; 6th, 940 feet; 7th, 1090 feet; and the occasional force of each source was very great. Similar occurrences are frequent in the neighborhood of London, and are familiar to all miners. But it is not enough that the structure of the country is such that water can percolate between different strata; the phenomena of Artesian fountains could not be explained without supposing it to be collected in large quantities, and forming subterranean reservoirs of immense extent. That such reservoirs exist, no doubt can be entertained. The celebrated fountain of Vaucluse sends forth at all times a stream of water sufficient to form a considerable river. Even in the driest seasons, when the water is least plentiful, it produces 5780 cubic feet per minute. After great rains, its product is thrice as great. The mean quantity emitted is 9360 cubic feet per minute, or about 5032 millions of cubic feet in a year. Many other examples of the same kind might be cited; showing that water must not only be collected in subterraneous cavities in immense quantities, but that it also passes freely from one place to another. In fact, the disposition of the rocks in strata permits the water to be collected under the surface, and to be conveyed without waste, as if in close pipes.

According to the view which has now been taken of the manner in which subterraneous water is collected, its elevation to the surface through a natural fissure or artificial perforation is a simple result of hydrostatic pressure. Generally speaking, it is only on the acclivities of hills, or in elevated places, that the edges of the strata are exposed, and where, consequently, the rain water can be received under beds of impermeable materials. Conceive two strata of clay, or rocks, as *a* and *b*, having a bed of sand or other matter permeable to water interposed, and suppose that *d* is the place where the edges of the strata drop out, or where a fissure allows a free entrance of the water to the permeable stratum. The water at first descends through the effect of gravity; it then passes along towards *b* in consequence of the pressure exercised by the superior part of the column near *d*. Now suppose a perforation to be made at *e*, and continued till it reaches through the stratum *a*, the water will naturally continue to rise till it gains the same altitude as *d*, or at least till it reaches the surface, if below that altitude. The water in fact between the two impermeable strata is in the same circumstances as in an artificial pipe; and if the surface of the ground at *e* is considerably lower than *d*, the ascensional force may be sufficient to cause a considerable jet.



Some Artesian fountains, for example that at Lillers in Artois, are situated in the middle of immense plains, where not the most insignificant hill is to be seen on any side. In such cases it may be inquired where we are to look for those hydrostatic columns whose pressure causes the rise of the subterraneous water to the level of the lowest points? The answer is obvious: we must suppose them placed beyond the limits of view; at the distance of 50, 100, or 200 miles, or even at a greater distance. The necessity of supposing the existence of a subterraneous liquid column of two or three hundred miles of extent, cannot appear a serious objection, when it is considered that the same geological structure has been found to prevail sometimes over even a much greater extent of country.

The water which rises in Artesian wells of great depth is remarkably warm, and is used for heating greenhouses and dwellings, and for washing purposes.

There are no geological capabilities in this country for the sinking of Artesian wells to any depth, or for any certainty; they are chiefly sunk in beds of the upper secondary formation, which have not at all the same extent of development on this as on the Eastern hemisphere.

The fountains in the parks of New York and other cities, act upon the same principle as Artesian wells: thus in New York, the water which is thrown up in Union Square and the Park has a tendency to rise to the height of the surface of the water in the lower distributing reservoir.

ASBESTUS—AMIANTHUS.—A mineral in which the long-needle crystals have a fibrous appearance. It is a variety of hornblend or tremolite, so soft in texture as to be spun and woven in flax, and from its incombustible nature, the cloth made of it may be cleansed when dirty by burning it. The ancients wrapped their dead in this cloth before burning, to keep the ashes from mixing with the fire. The Greenlanders use it for the wicks of lamps. In the Pyrenees, girdles are made of it, which are much prized. There are many varieties, as *ligniform*, or *woodlike asbest*, which is so hard as to be cut and polished; the fibres are less close in *mountain leather*, and *rock cork* is so light as to float upon water. Asbestus is made up of silica, magnesia, lime and iron.

ASHLAR. In architecture, common freestones, as they are brought rough and chipped, or detached from the quarry, of different lengths and thicknesses. Their usual thickness is nine inches.

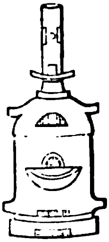
ASHLERING. In architecture, the upright timber or quarters towards the rooms, or inwards in garrets, by which the slope of the roof is concealed,—sometimes it is only two or three feet high, and sometimes the whole height of the room.

ASPHALTUM. A black brittle bitumen, very fusible and inflammable; it is soluble in naptha, and forms a good varnish. It is found upon the surface and banks of the Dead Sea (hence called Asphaltic Lake), and in large quantity in Trinidad and Barbadoes. The ancients employed it in some of their cements, and it was used also in the art of embalming. It probably exists on this continent, in Nova Scotia and New Brunswick, and in South America, at Coxitambo. It has of late been much used as a cement-paving, for which purpose the asphalte is melted, and mixed with sand and carbonate of lime, and run into moulds, forming blocks, weighing above 100 lbs. each. For roads, it is spread upon a thick layer of concrete; it is also used for lining cisterns and rendering surfaces waterproof. This cement has the advantage of being very easy of repair, it being only necessary to warm the imperfect part, and cut it away with the knife, it may then be melted and poured into the deficiency, and made to assume the proper shape. The asphalte rock is a lime rock, containing 80 per cent. of carbonate of lime and 20 per cent. of bitumen.

ASSAY, ASSAYING. A branch of chemical analysis. It is a process by which the quality of gold or silver bullion, trinkets, plate and coin is ascertained with precision, or by which the quantity of either of these precious metals may be determined in an alloy. It is now extended to determine the quantity of platinum and palladium in certain bullion and gold dust from Brazil. The art of assaying depends upon the fact that gold and silver have but a very feeble affinity for oxygen in comparison with copper and tin, and these latter, when oxydized, unite with lead, and sink with it into any porous earthen vessel. This vessel, or cupel, may be made of leached wood-ashes, or of burned bones, well powdered.

Cupellation, as this operation is called, is usually carried on in a small furnace, capable of being heated so as to melt gold. In the annexed cut, fig. 1 represents the furnace, which is lighted with charcoal when an assay is to be made.

FIG. 1.



In the middle of this furnace when heated, is placed an earthen vessel called a *muffle*, fig. 2 (comparatively enlarged), which is of an oven form, vaulted above and flat below, open at one end and closed elsewhere, except by a few narrow slits at the top and sides. The body of the muffle is surrounded with coals, and before cupellation is gradually heated to a cherry red. Its use is to protect the small cupels ranged on its floor from any impurities of fuel, and at the same time to afford it plenty of air to oxydize the metals. The cupels are little bone dishes, made of the materials stated previously moistened into a paste, and pressed into a shape by a cast-iron mould, which fig. 3. represents.

FIG. 2.

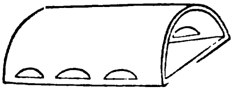
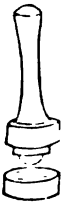


FIG. 3.



From 12 to 35 grains is the proper quantity of alloy to be weighed out for examination. It is wrapped up in lead-foil or paper, and surrounded by the thin plate of lead, they are then placed upon the cupel and laid in the muffle lying in the furnace, heated red hot, when they immediately melt. The lead oxidizes, and the oxide of lead formed, melts and runs down the sides of the mass into the body of the cupel. The button of alloy becomes smaller and brighter, and ultimately leaves the silver in a state of great purity. The quantity of lead necessary to carry out this experiment is a matter of nicety; if too much be used, some silver will be lost; if too little, the copper will not be removed from the alloy. In every assay, by this way, a little silver does seem to be lost. The operation being now finished, the cupel is cooled, and the button of pure metal weighed. The difference between it and the original weight gives the amount of alloy present.

A gold assay is more complex than a silver one. The copper alloyed with gold cannot well be separated by heat alone: some silver requires to be added for this purpose, which entails the necessity of a subsequent operation to remove the silver. In coins and manufacture, gold is often mixed with silver, and the operation of separating them is termed *parting*, which consists in treating the mass with dilute nitric acid, which dissolves the silver out and leaves the gold. If the amount of silver be small, it is necessary to add some silver to it, for in that case the gold preponderating, the silver is protected from the action of the acid. After the acid has removed all the silver and copper, the insoluble metal remaining is placed on the cupel and heated in the furnace, it is then cooled and weighed, and the weight indicates the absolute quantity of gold in the sample.

Assaying is extended to copper ores, to determine the value of a sample, as to the amount it should produce in the smelting furnace, or whether it be worth working. Assays may be conducted by the assistance of heat and fluxes, or in the *dry way* as it is termed, or else in the *moist way*, as by acids or other reagents; the former is the readier mode, the latter the more correct. Berthier's work on "Assays by the Dry Way," and Mitchel's "Manual of Practical Assaying" may be consulted for further information.

ATOMS, OR ATOMIC WEIGHTS, are the original quantities in which bodies either simple or compound combine with each other, referred to a common body taken as unity. Oxygen is taken as the standard by some, and hydrogen by others. The atomic weight of a substance is its lowest combining figure: thus if oxygen unites with bodies in several proportions, the lowest of which is 8, then 8 is said to be the atomic weight of oxygen; it is better termed its equivalent, or its combining proportion. A knowledge of chemical equivalents, or atomic weights, is of great use to the manufacturer, as it informs him in many cases of the proper quantity of one substance to be mixed with another, and thus saves him from waste or loss. The subjoined is a list of the equivalents of the elementary bodies from which the atomic weights of many of the compounds may be calculated. Those substances which have no figures attached, have not had the equivalents correctly determined:

Hydrogen,	1
Oxygen,	8
Carbon,	6
Boron,	11
Phosphorus,	32
Sulphur,	16
Selenium,	40
Iodine,	126
Bromine,	78
Chlorine,	35
Fluorine,	19
Nitrogen,	14
Potassium,	40
Sodium,	24
Lithium,	7
Barium,	69
Strontium,	44
Calcium,	20
Magnesium,	12
Lanthanum,	14
Cerium,	46
Didymium,	
Erbium,	
Terbium,	
Yttrium,	32
Glucinum,	5
Aluminum,	11
Thorium,	60
Zirconium,	23
Silicium,	15
Titanium,	24
Tantalum,	185
Niobium,	
Pelopium,	
Tungsten,	101
Molybdenum,	48
Vanadium,	68
Chromium,	28
Uranium,	60
Manganese,	28
Arsenic,	75
Antimony,	129
Tellurium,	64
Bismuth,	213
Zinc,	32
Cadmium,	56
Tin,	59
Lead,	104
Iron,	28
Cobalt,	30
Nickel,	28
Copper,	32
Mercury,	100
Silver,	108
Gold,	200
Platinum,	99
Palladium,	54
Rhodium,	52
Iridium,	99
Osmium,	100
Ruthenium,	

AUGER. An instrument for boring the soil for the purpose of ascertaining the nature of the subsoil, the mineral, and in agriculture more especially, the existence of water. There are various kinds of augers, according to the purposes to which they are to be applied; but they all consist of three parts, viz. the bit, mouth, or cutting piece, the handle, and the connecting rods. The handle is for the purpose of working the instrument by the means of two or more men, the rods for connecting the handle with the bit or cutting piece, and the bit for penetrating the soil. When it is necessary to pass through stony soil or rocks, a chisel is substituted for the bit: and after the rock is broken in small pieces, the chisel is removed, and replaced by the common auger, by which the loose matters are drawn up.

AURUM MUSIVUM. Mosaic gold. An obsolete name for the bisulphuret of tin.

AUTOMATON. A name applied to pieces of mechanism so constructed as to imitate the actions of living animals. The term Android is sometimes applied to such machines as resemble the figures and imitate the actions of mankind.

The extent to which these useless but ingenious contrivances has been sometimes carried is very surprising. Archytas of Tarentum, about 400 years before our era, is said to have made a wooden pigeon that could fly. Friar Bacon's speaking head is a well-known tradition. Albertus Magnus constructed an automaton to open his door when any one knocked; the celebrated Regiomontanus, a wooden eagle that flew forth from the city, saluted the emperor, and returned: and likewise an iron fly which flew out of his hand, and returned after flying about the room. These instances may perhaps have been exaggerated in the description; but there are some of recent date, and not less remarkable, respecting which the testimony is clear and strong. The following are a few of the best authenticated: The flute-player of Vaucanson, described by D'Alembert in the *Encyclopedie Methodique*, was exhibited in Paris in 1738. It played on the flute exactly in the same manner as a living performer, and commanded three octaves, the fullest scale of the instrument. Its height was nearly six feet. In Hutton's *Mathematical Recreations*, a description is given of an automaton group, constructed by M. Camus for the amusement of Louis XIV., consisting of a coach and horses, with coachman and page, and lady inside, &c., by which the action of driving up, alighting, presenting a petition to the king, and setting off again, was mimicked with wonderful accuracy. In 1741, Vaucanson produced a flageolet-player, which played the flageolet with the left hand, while it beat a tamborine with the right. He also produced a duck which dabbled in the water, swam, and drank, and quacked like a real duck; raised and moved its wings, dressed its feathers with its bill, took barley from the hand and swallowed it, and even digested its food by means of materials for its solution placed in the stomach.

Automaton flute-players have likewise been exhibited in England of the size of real life, which performed ten or twelve duets. Maelzel, the inventor of the metronome, exhibited an automaton trumpeter at Vienna, of which a description is given in the *Journal des Modes* for 1809. It was a martial figure, in the uniform of a trumpeter of an Austrian dragoon regiment, which played not only the Austrian and French cavalry marches, and all the signals of those armies, but also a march and an allegro, by Weigl, accompanied by the whole orchestra, &c.

Automata have also been constructed which wrote, drew likenesses, played on the pianoforte, &c.

Professors Willis and Wheatstone have improved very much a speaking automaton; and one made by a German was exhibited a few years ago in London.

AVANTURINE—ARTIFICIAL. MM. Fremy and Clemandot have lately rediscovered the mode of making this beautiful article, which has hitherto remained a secret with the glass-blowers of Venice. Having unsuccessfully tried the action of different metals on glass, colored by oxide of copper, they examined the reduction which oxides of the minimum oxydation exercised on the protoxide of copper, and chiefly that of the protoxide of iron of the forges. Under heat this oxide readily reduced the protoxide of copper to metallic copper, and produced a metallic oxide soluble in glass, and giving it a slightly yellow tint. Heating 300 parts of pounded glass, 40 parts of protoxide of copper, and 80 parts of oxide of iron, they obtained a glass containing abundant crystals of metallic copper. The appearance of this avanturine is somewhat more opaque than the Venetian articles; but it is no doubt produced in a similar way. The Venetian avanturine fetches a very high price.

AXE-STONE. A silico-magnesian mineral, sometimes shaped by the Indians into cutting instruments. A variety of nephrite.

AXINITE. A mineral found in axe-shaped crystals. An alumino silicate of lime and iron.

AXIS. In architecture, a real or imaginary straight line passing through any body on which it may revolve. The axis of a column, for instance, is a straight line drawn down through its centre; the axis of the Ionic volute is a line drawn through the two eyes, front and rear.

In mechanics, it signifies in general the straight line, real or imaginary, about which a body turns. In this sense it is called the axis of rotation, of oscillation, &c., according to the motion of the body. In geometry, the axis of a figure is a straight line about which the parts of the figure are symmetrically disposed. Thus the axis of a cone is the line drawn from the vertex to the centre of the base; and the axis of a cylinder, the line drawn through the centre of its two ends. In the ellipse and hyperbola, the transverse axis is the straight line drawn through the two foci; and the conjugate axis, that drawn through the centre, perpendicular to the transverse. In general, by the axis of a curve line is meant that diameter which has its ordinates at right angles to it. We also speak of the axis of the co-ordinates of a curve, meaning the line on which the abscissa are taken.

AXLE. (*See* WHEEL CARRIAGES.)

AXUNGE. Hogs lard.

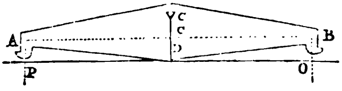
AZURE. A fine blue pigment: being a glass colored with oxide of cobalt, and ground to a very fine powder. (*See* SMALTS.)

BAGASSE. The refuse of the sugar cane as delivered from the mill.

BAKING. The process of drying and consolidating a substance by the aid of heat.

BALANCE. A machine for weighing substances. The process of weighing may be performed in various ways, and accordingly there are several kinds of balances; as the common balance or scales, the bent lever balance, the spring balance, the steel-yard, the hydrostatic balance, &c. The term is also applied to any apparatus employed for comparing the intensities of very small forces; as the electric balance, the balance of torsion, &c. We shall here confine our remarks to the philosophical balance, the instrument used when great accuracy is necessary; for instance in assaying, and in the more delicate investigations of physics and chemistry.

Neglecting the mere circumstance of construction, and the particular methods of suspension, the balance may be represented thus:



A and B are the points from which the scales are suspended at the extremities of the beam, C the point of support, G the centre of gravity of the beam, D the point in which the straight line C G intersects the straight line joining A and B.

The properties required in a good balance are *sensibility* and *stability*. The balance must be sensible; that is to say, when it is properly poised a very small addition of weight to either scale should disturb the equilibrium, and cause the beam to turn; and it must be stable, that is to say, when the equilibrium has been disturbed it should quickly return, and oscillate about the position of rest. These two properties are in some degree opposed to each other: in order to attain them both, as far as possible, it is necessary to attend to certain mechanical principles, as well as to the physical circumstances of construction. Let us suppose

W = the weight of the beam.

L = the load, *i. e.* the weight of the scales and whatever is in them when the beam is poised.

P = the preponderating weight, or that which causes the beam to turn.

Suppose now the beam to be poised, or that the scales being loaded the position of the line A B is perfectly horizontal. The sensibility will evidently be measured by the angular space through which the beam turns when a small weight P is added to either scale: but the force which acts in turning the beam is proportional to $P \times D B$, that is, proportional to the weight multiplied into the length of the lever at the extremity of which it acts; therefore for a given weight P, the sensibility of the balance, all other circumstances being equal, is proportional to the length of the beam. Let us next consider the force which tends to restore the beam when the equilibrium is disturbed. This is made up of two parts; the first of which is proportional to $W \times C G$, that is to say, proportional to the weight of the beam (which may be regarded as concentrated at the centre of gravity) multiplied into the length of the lever on which it acts; and the second proportional to $L \times C D$, that is, to the load also multiplied into its length of lever. The whole restoring force is therefore proportional to $W \times C G + L \times C D$. Now this force is precisely that which the preponderating weight P has to overcome in turning the scale; consequently any circumstance which tends to increase it, increases the stability and diminishes the sensibility of the balance; and any thing which tends to diminish it, diminishes the stability and increases the sensibility. By bending the arms of the balance, or altering the points of suspension of the scales, the points G and D may acquire different positions relatively to C. Supposing G to be above C in the vertical line joining those points; the term $W \times C G$ would become negative, and the restoring force proportional to $L \times C D - W \times C G$. In this case, if the load L, or the distance C D, were diminished till $L \times C D$ became less than $W \times C G$, the balance would be useless; because if moved ever so little from the position of rest, it would have no tendency whatever to return. The best construction is to make $C D = 0$, that is, to place the three points of action A, C, B, in the same straight line, and to construct the beam so that G, the centre of gravity, shall fall a little below the line A B. The sensibility is then independent of the load, and is simply in the inverse portion of $W \times C G$; so that by diminishing the weight of the beam, or the distance C G, it may be increased to any required degree. It is supposed that the two arms are precisely of the same length, or that C is placed exactly in the middle between A and B, and also that they are perfectly inflexible.

The conditions now determined from theory must be the guide of the artist in the construction of a good balance. It is of importance that the beam be as light as possible, consistent with inflexibility; for not only the inertia, but also the friction, is increased in proportion to the weight, and the sensibility consequently diminished. In order to give lightness and strength at the same time, the beam should be formed of two hollow cones of brass, joined together at the broad ends.

A cylinder of steel, passing through the middle of the beam at right angles, forms the axis; and its extremities, ground into sharp edges on the lower side, serve as the points of support. The two edges must be accurately in the same straight line, and turn on smooth planes of agate or polished steel carefully levelled. The scales should likewise be suspended from the extremities of the beam on knife edges, crossing each other at right angles; those in the beam being sharp upwards, and those to which the scales are attached sharp downwards. A needle, or tongue, is usually attached to the beam, pointing directly upwards or downwards when the beam is horizontal, for the purpose of indicating the deviations of the beam from the horizontal position on a graduated scale. It is better, however, to bring the arms to terminate in sharp points, and to place a scale behind each; in this way the slightest flexure of the beam will be rendered evident, if the zeros of the scales are placed exactly in the same level. The scale is indispensably necessary, because the balance, if very sensible, would require a long time to come to rest; but it is known to be poised, when the excursions of the needle on both sides of the zero of the scale are equal. In order to preserve the knife edges, the beam, when not in use, is supported on rests. Props should also be placed under the scales while loading or unloading the balance. The whole apparatus must be placed under a glass case, to protect it from the disturbing influence of currents of air.

The sensibility of a balance constructed with due care, according to the principles now explained, may be carried to an almost inconceivable extent. There is one in the possession of the Royal Society, made by Ramsden, which weighs ten pounds, and is said to turn with the ten millionth part of that load, or the thousandth part of a grain. Nevertheless, whatever skill may be employed in the construction, it is plain that the conditions necessary to mathematical accuracy can never be entirely fulfilled. It is impossible to make the two arms of the beam exactly similar, or exactly equal in length. Absolute precision is unattainable in practice. This difficulty, however, may be overcome by the following simple method, imagined by Borda, by which accurate results are obtained independently of extreme precision in the construction of the balance: it is only necessary that it be very sensible. Let P, the substance to be weighed, be placed in the scale A; instead of placing known weights in the scale B, put into it some other substance, for instance bits of iron, chips of wire, or sand, added in minute quantities till the substance P is exactly counterpoised, or the beam becomes exactly horizontal. This being done, let the substance P be gently removed out of the scale A, and let known weights, as grains, be put into it till the substance in the scale B is again exactly counterpoised. It is now of no consequence whether the balance was accurate or not, or whether the body P was exactly equal in weight to the substance against which it was weighed in B. The weight of P must be precisely equal to that of the grain weights; because, under exactly the same circumstances, they both formed a counterpoise to the substance placed in B.

Chinese Balance. This is formed of a slender tapering rod of wood or ivory, about a foot in length. A silk thread passed through a hole perforated nearer one of its extremities than the other, serves as the point of suspension. The balance has thus two unequal arms. From the extremity of the shorter a small scale is suspended to hold the substance to be weighed. A sliding weight passes along the other arm, on which divisions are marked; and when the counterpoise is made, the distance of the standard weight from the fulcrum indicates the weight of the substance. In order to procure a greater range, the rod has generally four holes or points of support, at different distances from the extremity, and a corresponding set of divisions is marked on each of its four sides. The principle of this machine is exactly the same as that of the common steelyard.

The *Danish Balance*, much used in the north of Europe for weighing coarse commodities, is usually formed of an iron bar or a batten of hard wood, having a lump of lead at one of its extremities. The goods are fixed on a hook in the other end; and the whole is suspended through a loop of cord, which is passed backwards and forwards under the rod till equilibrium is obtained. The weight of the goods is then to the weight of the lead reciprocally as their respective distances from the loop.

Roman Balance or *Steelyard.* (*See* STEELYARD.)

BALCONY. In architecture a projection from the external wall of a house, borne by columns or consoles; usually placed before the windows or openings.

BALLAST. Is a mass of weighty material placed in the bottom of a ship or vessel to give her *stiffness;* that is, to increase her tendency to return to the upright position when inclined or *heeled over* by the force of the wind or other cause. Ballast consists of shingle (the coarse gravel of the sea-beach), stones, &c. This tends to give excess of stability, which renders the vessel *uneasy* from the suddenness of the motion: this defect is remedied by *winging* up the ballast, whereby its centre of gravity is raised. For the like reason in stowing the ballast it is tapered to a point at the fore and after extremities. Iron ballast, from the greater cleanliness, is more healthy for the crew than that of other materials. When a ship has no other loading, she is said to be *in ballast.*

The quantity of ballast and the mode of its stowage differ greatly in different vessels; and the connection between the motions of a ship and her stowage has not yet been analyzed sufficiently to lead to the discovery of direct rules on these important points.

BALL-COCK. A hollow sphere or ball of metal attached to the end of a lever, which turns the stop-cock of a cistern pipe, and regulates the supply of water. As the surface of the water rises in the cistern, the ball is raised by its buoyancy; and as the water descends, it falls by its own weight. The cock is thus closed when the water rises to a certain height, and the supply stopped; but when a part of the water is drawn off from the cistern, the cock is again opened, and the water admitted through the pipe.

BALLISTIC PENDULUM. An instrument, invented by Benjamin Robins, for measuring the force or velocity of cannon and musket balls. To one extremity of an iron bar is fixed a heavy cubical block of wood, lined at the back with iron. A transverse bar of iron at the other extremity of the first bar serves as an axis of suspension, in which the pendulum swings freely backwards and forwards. The instrument being thus fitted, if the weight of the pendulum be known, and likewise the respective distances of its centres of gravity and oscillation from the axis of suspension, it is easy to determine the quantity of motion that will be communicated to the pendulum by the percussion of a body of a given weight moving with a given velocity and striking it at a given point. Conversely, if the pendulum, when at rest, is struck by a body of a known weight, and the vibration which the pendulum makes after the blow is known, the velocity of the striking body may thence be determined. In order to measure the extent of the vibration, a riband is attached to the lower end of the pendulum, passing loosely through an orifice in a horizontal bar in the frame-work: when the pendulum is raised it draws the riband along with it, and the quantity which thus passes through the orifice measures the chord of the arc of vibration.

BALLOON. (Fr. ballon, *a little ball.*) The name of a machine, which, consisting of an envelope containing a gas specifically lighter than common air, rises into the atmosphere with a greater or less degree of ascensional force. A car, supported by a net-work which extends over the balloon, supports the aëronaut: and a valve, usually placed at the top, to which a string is attached reaching to the car, gives him the power of allowing the gas to escape, and of descending at pleasure.

During the dark ages, and for some time after the revival of science, numerous projects were entertained for navigating the air; but it is only in very recent times, since 1783, that any of them have been realized. The first idea was to employ some mechanical contrivance resembling the wings of birds; but Borelli demonstrated that all attempts on the part of man to fly must necessarily fail, from the utter disproportion of his muscular power to the force that would be necessary to give impulsion to wings of such enormous magnitude as would be required to sustain his weight in the air.

The principle by which a balloon rises in the atmosphere is exactly the same as that which causes the ascent of a cork from the bottom of a vessel filled with water. The weight of the volume of air which it displaces must exceed the weight of the balloon and all that it carries with it. That bodies must rise and remain suspended in a fluid denser than themselves was proved by Archimedes; but the weight of the air is a modern discovery; and it was only in the latter half of the last century that chemistry detected the nature and differences of specific gravities of aëriform fluids. Mr. Cavendish, in 1766, by some ingenious experiments, recorded in the *Philosophical Transactions*, vol. lvi., found hydrogen gas to be from about seven to eleven times lighter than common air, according to the mode of its preparation. In its pure state it is found to be nearly sixteen times lighter than common air. This substance, therefore, if prevented from diffusing itself, and allowed to obey the force by which it is impelled upwards, will continue to mount till it arrives at a stratum of the atmosphere sixteen times more attenuated than at the surface of the earth. Accordingly, no sooner had Cavendish announced his discovery, than it occurred to Dr. Black that a very thin bag filled with hydrogen gas would mount to the ceiling of a room. Through some imperfection, the experiment when he attempted to execute it failed: and it was several years later before an envelope was thought of sufficiently light, and at the same time impermeable to the gas. Cavallo made a series of experiments on this subject in 1782, but did not succeed in raising any thing heavier than a soap-bubble. The expense attending the preparation of the gas probably prevented the experiment from being made on a great scale.

Knowing the specific gravities of atmospheric air, of the gas with which the balloon is to be filled, and the weight of the envelope in which it is confined, it is not difficult to compute the size the balloon must have in order to rise from the ground, or carry a given weight to a given height in the atmosphere. A globe of air, one foot in diameter, at the level of the sea and under the ordinary pressure, weighs about 1-25th of a pound avoirdupois. An equal globe of hydrogen gas, obtained in the usual way by dissolving iron filings in dilute sulphuric acid, may be assumed (making every allowance for imperfect preparation) to be about six times lighter than atmospheric air; consequently 5-6ths of its whole buoyant force will act in impelling it upwards: that is to say, the force with which a sphere of such gas, one foot in diameter, will tend to rise in the atmosphere, will be $\frac{5}{6}\times\frac{1}{25}=\frac{1}{30}$ of a pound avoirdupois. The ascensional forces of different spheres will be proportional to their magnitudes, that is to the cubes of their diameters: therefore a sphere 12 feet in diameter would rise with a force of 57 pounds, and one of 24 feet in diameter with a force of $8\times57=456$ pounds. But these determinations must be diminished by the weight of the envelope. The best material for the purpose at present known is thin silk varnished with elastic gum, or Indian rubber. The quantity of this material required to cover a globe one foot in diameter, weighs about 1-20th of a pound. Now for a globe of a greater size, the quantity required will increase with the square of the diameter; hence the covering of a balloon 12 feet in diameter must weigh about 7 pounds, and of one 24 feet in diameter 28 pounds. It follows, therefore, that a balloon of 12 feet diameter will only raise from the ground a weight of 50 pounds, and one of 24 feet 428 pounds. Computing in the same manner, it is found that a balloon 60 feet in diameter would raise a weight equal to about 6,950 pounds; and that one of a foot and a half would barely float, the weight of the bag being just equal to that of the imprisoned gas.

The height to which a balloon will rise is determined from the law according to which the density of the atmospheric strata diminishes as the distance from the earth is increased. The buoyant force diminishes with the density; and when it is reduced to a quantity only equal to the weight of the balloon and its appendages, no further ascension can take place. Another circumstance also confines the possible elevation within moderate limits. As the pressure of the external air is diminished, the expansive force of the confined gas becomes greater, and would ultimately overcome the resistance of any material of which a balloon can be made. A balloon quite filled at the surface of the earth would inevitably be torn to shreds at the height of a few miles in the atmosphere, unless a portion of the gas were allowed to escape. For this purpose the balloon is furnished with a safety valve, which can be opened and shut at pleasure; but to prevent unnecessary waste of gas, it ought to be made of such a size that it requires only to be partly filled. A balloon half filled at the surface of the earth would become fully distended at the height of 3½ miles.

We have hitherto spoken only of balloons filled with hydrogen gas; but it is evident that any other substance specifically lighter than air would answer the purpose; in fact, the first balloons by which any one was raised into the atmosphere were not filled with hydrogen, but simply with rarefied air, the rarefaction being produced by kindling a fire under them; and as they thus became filled with smoke, they were called smoke-balloons. The ascensional force, however, which can be gained in this way is not great; besides the aëronaut must carry a portion of fuel with him for the purpose of maintaining the fire, which adds sensibly to the weight to be raised. The keeping up of the fire is also attended with inconvenience, and even danger.

Two brothers, Stephen and Joseph Montgolfier, proprietors of a paper manufactory at Annonay in France, have the honour of first preparing and sending up a balloon into the air. After one or two previous trials, they announced a public ascent on the 5th of June, 1783. The balloon was prepared of linen cloth; a fire was kindled under it, and fed with bundles of chopped straw. This substance was used with a view to produce a large quantity of smoke. It would seem that they attributed the elevation of the balloon to the ascending power of the smoke, instead of its true cause, the rarefaction of the heated air. In the space of five minutes it was completely distended; and on being let slip, ascended rapidly. It reached an elevation of about a mile, remained suspended ten minutes, and fell at the distance of a mile and a half from the place of its ascension. When the news of this experiment was carried to Paris, the surprise was general, and the virtuosi began immediately to consider how it could be repeated. It was determined to apply hydrogen gas on this occasion; and Charles, a celebrated lecturer on natural philosophy, undertook the superintendence of the process. On the 26th of August, 1783, the preparations were complete, and the balloon was transported with much ceremony to the Champ-de-Mars. On the following day, at five o'clock in the afternoon, the report of a cannon announced to the assembled multitude that every thing was ready. "The globe, liberated from its stays, shot upwards, to the great surprise of the spectators, with such rapidity that in two minutes it reached the height of 3000 feet. It traversed successively several clouds, by which it was repeatedly obscured. The violent rain which began to fall at the moment of its ascent did not retard its rapid progress, and the experiment was attended with complete success. The satisfaction was so great that even elegantly dressed ladies remained with their eyes intently fixed on the balloon, regardless of the rain, which fell on them in torrents." (*Libes. Dictionnaire de Physique.*) This balloon remained in the atmosphere only three quarters of an hour; it fell at a distance of about fifteen miles, when it was discovered that a rent was made in the upper part, through which the gas had escaped.

The first adventurers who had courage to undertake an aërial ascent in a balloon, were Pilatre de Rosier, a young naturalist, and the Marquis d'Arlandes. On the 21st of November, 1783, they took their seats in the basket of a smoke balloon; and after rising to an elevation of upwards of 3000 feet, descended safely to the earth. The next ascent was made by MM. Charles and Robert in a balloon filled with hydrogen gas, on the 1st of January, 1784. After a flight of a hour and a half they alighted on the meadow of Nesle, about twenty-five miles from Paris, without the slightest accident. As the balloon still retained a considerable buoyant force, M. Charles resolved on another ascent alone. It rose to the height of near two miles in about ten minutes; and the aëronaut had the satisfaction of seeing the sun, which had set when he left the earth, again rise above the horizon. After remaining about thirty-five minutes in the air, he descended safely at a distance of about nine miles from the spot from which he had risen.

So many aërial voyages executed with safety encouraged other attempts; and no accident occurred till the accomplished Pilatre de Rosier, with his companion Romain, were killed in an attempt to cross the channel from France to England. On the 13th of June, 1785, they ascended from Boulogne. Under the principal balloon, which was of hydrogen gas, they had suspended, for the purpose of increasing or diminishing the ascensional power at pleasure, a smoke balloon, which occasioned the disastrous issue. Scarcely a quarter of an hour had elapsed when the whole apparatus, at the height of 3000 feet, was perceived to be on fire, and the unfortunate voyagers were precipitated to the ground. This calamitous occurrence, however, did not damp the courage of aëronauts. It was obvious that it had been occasioned by the want of proper precautions; accordingly ascents continued to be multiplied, and have since become so common as to be an ordinary spectacle in the principal cities of Europe.

When balloons first began to be constructed, it was expected that they would be found applicable to many important purposes. These expectations have been disappointed, chiefly because it has been found impossible to guide or control their course. The only power the aëronaut possesses over his balloon is to regulate its elevation within certain limits. In one or two instances they have been successfully used for military reconnoissance. The victory which Jourdan obtained over the Austrians at Fleurus, in 1794, was ascribed to the knowledge obtained of the enemy's movements by means of a balloon. A very interesting ascent was made by Biot and Gay Lussac, in August 1804, and by Gay Lussac alone in September of the same year, with a view to make meteorological observations in the upper strata of the atmosphere. In the first voyage, the two philosophers, at an elevation of between 9,500 and 13,000 English feet, found the oscillations of the magnetic needle to be performed in the same time as at the surface of the earth. At 12,800 feet the thermometer, which stood at 63¼° at the observatory, had sunk to 51° of Fahrenheit, being only a decrease of 1° for every thousand feet. The hygroscope indicated increased dryness in proportion to the elevation. In the second ascent, performed by Gay Lussac alone, the variation of the compass at the height of 12,680 was found to remain unaltered. At 14,480 feet, a key held in the magnetic direction attracted with one end and repelled with the other the north pole of the magnetic needle. The same was the case at 20,150. At 18,000 feet the thermometer fell to the freezing point, and at 22,912 feet to 14·9° of Fahr. Two flasks, which had been previously emptied of air, were opened and filled at an elevation exceeding 21,400 feet; and the air brought down from this region was found, on being analyzed, to contain exactly the same proportions of the constituent elements as at the surface. The utmost elevation which he reached was 23,040 feet, or four miles and a quarter above the level of the sea, considerably higher than the loftiest peak of the Andes.

Excepting in these two remarkable ascents of Gay Lussac, nothing has been gained to science by the use of balloons. The numerous other ascents undertaken, both before and since, have as yet served no other purpose than to gratify idle curiosity; and from the total failure of every scheme that has been proposed for directing their course through the air, there is little reason to anticipate any great advantages from them to society. Nevertheless, the comparative cheapness and facility with which they can be filled by coal gas, now so generally used for the purposes of illumination, have been the cause of directing public attention to the subject. Mr. Green crossed the channel from Vauxhall to Nassau, in Germany, in 1836, after a journey of eighteen hours, carrying two companions and a ton of ballast. This feat (crossing the English Channel), has been repeated since more than once,—the last voyage being in the spring of 1851 from London, and landing within a few miles of Boulogne.

BALSAMS. Exudations from and juices of certain plants which are liquid, or soft-solid, and consist of a substance resembling resin either combined with Benzoic acid or an essential oil, or both. The principal balsams are those of Peru, Tolu, Benzoin storax, and liquidambar. Those contain Benzoic Acid, while Copaiva balsam, Mecca balsam, and Japan-lac do not.

BALUSTRADE. A parapet or protecting fence formed with balusters.

BANDANA. (*See* CALICO PRINTING.)

BARBERRY. (*See* BERBERRY.)

BARILLA. The name given to the impure carbonate of soda imported from Spain and the Levant. It is the ash of the salsola soda and other plants, which are grown on the shore for the purpose of supplying the ash. It seldom contains more than 20 per cent. of real alkali, besides sulphates and chlorides of soda, lime, and alumina, with some sulphur. It was much used in soap manufacture; it is now almost entirely superseded by the carbonate of soda obtained from common salt.

BARIUM. The metallic base of baryta. It is a white metal, of the color and lustre of silver, malleable, fusing below a red heat, oxidizing in the air, and decomposing water. The oxide of barium or baryta is abundant in nature, as carbonate and sulphate of baryta, forming the vein-stone in many lead mines. Pure baryta is a white earth, resembling lime in its affinity for water and carbonic acid. Nearly all the baryta compounds are poisonous, except the sulphate. The best antidote is a solution of sulphate of soda. Baryta, of all substances, has the greatest affinity for sulphuric acid. The sulphate of baryta is used as a pigment "permanent white," and as an adulteration in white lead; it is also used in the manufacture of jasper and other earthen ware.

BARK. The outer covering of the trunk of the tree. It is the depository of many of the secretions of the plant, and generally contains a large quantity of *tannic* and *gallic* acids. The most important barks are those of the oak and cinchona trees: for which see *Tanning* and *Peruvian Bark*.

BARLEY. A valuable grain for malting, but a poor one for bread: the seeds of the Hordeum distichon. It grows well on light lands, and is used in fattening black cattle, hogs, and poultry. 30 bushels is a good crop of 68 lb. each, and the weight of the straw is about 1-6th more.

1000 parts of barley contain, according to Einhof, starch, 720; mucilage, 50; sugar, 56; gluten, 36·6; vegetable albumen, 12·3; water, 100; phosphate of lime, 2·5; ligneous matter, 68. Pot barley is barley deprived of its outer skin; pearl barley has also a portion of the grain removed, leaving merely a small round kernel. Both kinds are made in the same mill, but the pearl barley receives more grinding.

BARM. Another name for yeast. (See *Beer*.)

BAROMETER. A well-known instrument for measuring the weight or pressure of the atmosphere. The invention of the barometer was in some degree owing to an accident. Some workmen employed by the Duke of Florence to prepare a sucking-pump for a deep well, found to their surprise that notwithstanding the utmost care in forming and fitting the valves and piston, the water would not rise higher than 18 palms, or about 32 English feet. For an explanation of this unexpected difficulty they applied to the illustrious Galileo, then passing the evening of his life at his villa near Arcetri; but the philosopher was not yet prepared with the true answer. In that age the doctrine of a *plenum* was an axiom in philosophy; and the ascent of water in the barrel of the pump was universally ascribed to nature's horror of *a vacuum*. Galileo, either fearing to encounter further persecutions by propounding opinions at variance with the prejudices of the times, or pre-occupied by the prevailing metaphorical modes of expression, evaded the difficulty by saying that the power of nature to overcome a vacuum was limited, and did not exceed the pressure of a column of water 32 feet in height. That he was himself little satisfied with this explanation, is evident from the circumstance that previously to his death, which happened soon after, in 1642, he earnestly recommended to his pupil Torricelli to undertake the investigation of the subject, which the infirmities of advanced age no longer permitted him to prosecute. Torricelli, suspecting the true cause of the suspension of the water, namely, the weight of the atmosphere, happily conceived the idea of trying the experiment with mercury. He perceived that if the weight of the atmosphere forms a counterpoise to a column of water of 32 feet, it must also counterpoise a column of mercury of about 28 inches in height, the weight of mercury being about 14 times greater than that of water. Having accordingly procured a glass tube of about 3 feet in length and a quarter of an inch in diameter, hermetically sealed at one end, he filled it with mercury; and covering the open end with the finger, he immerged it in an open vessel containing mercury. On bringing the tube to the vertical position, and removing the finger, the mercury instantly sank, leaving a vacuum at the top of the tube, and, after making several oscillations, stood in the tube at the height of about 28 inches above the surface of that in the vessel. On covering the mercury in the vessel with a portion of water, and raising the tube till the lower end came into contact with the water, the mercury all ran out, and the water rushed up to the top of the tube. This experiment, called after its author the *Torricellian experiment*, demonstrated that the mercury was sustained in the tube, and the water in the barrel of the pump, by exactly the same counterpoise, whatever the nature of it might be. Torricelli died shortly after, in the flower of his age, without completing his great discovery; but the fame of his experiment was soon carried into other countries, and the subject engaged the attention of the most eminent philosophers; among others the celebrated Pascal. After a variety of ingenious experiments on the subject, all of which tended to establish the pressure of the atmosphere, it at length occurred to Pascal that if the mercurial column was really supported by atmospheric pressure, it must be affected by the weight of the superincumbent mass of air, and consequently be diminished at considerable elevations. In order to verify this conjecture, he requested his brother-in-law, Perier, to try the experiment on the *Puy de Dome*, a lofty conical mountain in the province of Auvergne, which rises to the height of 500 toises. At the foot of the mountain Perier filled two tubes, and observed the mercury in each to stand at precisely the same height, nearly 28 English inches. Leaving one of them under the care of a person to watch its rise and fall, he carried the other to the top of the mountain; and on repeating the experiment there, the mercury stood at the height of only 24·7 English inches. At two intermediate stations in his descent, the mercury was observed successively to rise, and at the foot of the mountain it stood at exactly the same height in the tube as at first. This experiment was decisive; the result of it was communicated to Pascal at Paris, who, after confirming it by similar observations made successively on the ground, and at the top of a glass-house and the belfry of a church, proposed the barometer as an instrument for measuring the height of mountains, or the relative altitudes of places above the surface of the earth.

The barometer had been but a short time invented before it was observed that the height of the mercurial column is subject to variations connected in some way with the changes of weather. But the variations are confined within a limited range, scarcely exceeding 3 inches in all, and often, for many days together, do not exceed a few hundredths of an inch. It therefore was considered desirable to render these minute oscillations more apparent by increasing their range; and accordingly, of the numerous forms which the barometer has received, or which have been suggested, the greater part have been proposed with a view to this purpose. The most remarkable or useful constructions are the following, the descriptions of which will be readily understood with the assistance of the diagrams:—

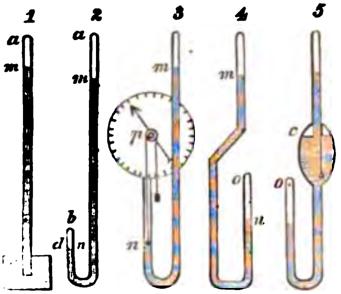


Fig. 1, is the *Cistern Barometer*, and is merely the inverted tube of Torricelli already described. The tube must be about 34 inches long. When placed in the cistern, the mercury sinks till the column between the two surfaces *m* and *n* just counterbalances the pressure of the air. The space above the mercury, *a m*, is or ought to be a perfect vacuum, or only filled with the vapor of mercury. In this barometer, as the diameter of the cistern is generally very much greater than that of the tube, almost the whole effect of the rise or fall is perceived in the variation of the upper surface at *m*. For supposing the section of the cistern 20 times greater than that of the tube, and that the height of the column *m n* suffers a diminution of one inch; it is evident that, as all the mercury which goes out of the tube passes into the cistern, when it falls at *m* it must rise at *n*, but less in proportion as the section of the cistern exceeds that of the tube. In the case supposed, therefore, the alteration of the level at *m* will be 20 times greater than at *n*; that is to say, there will be a fall of $\frac{20}{21}$ of an inch at *m*, and a rise of $\frac{1}{21}$ of an inch at *n*.

Fig. 2, is the *Siphon Barometer*, which was also proposed by Torricelli, as being more convenient than the former. It is merely a tube hermetically sealed at the upper end, having the lower or open end bent upwards in the form of a siphon. The variations in this are only half as great as in the cistern barometer; for the tube being of the same width throughout, a diminution of the column *m n* amounting to one inch will be marked by a fall of half an inch at *m* and a rise of half an inch at *n*. This inconvenience may, however, be remedied by having the lower branch blown into a wide bulb; but as it is very difficult to procure the bulb to be blown into a perfectly regular shape, this enlargement of the bulb is found to give rise to inaccuracies.

Fig. 3, is the *Wheel Barometer*, proposed by Hooke. A small weight floats on the surface of the mercury in a siphon barometer, which is very nearly counterpoised by another weight, *w*, connected with the former by a string passing over a pulley, *p*. When the mercury rises at *n*, the weight *w* descends, and turns the pulley. An index attached to the axle of the pulley shows on a dial the quantity of revolution. This barometer, though very commonly met with, is a mere toy; and indicates neither the absolute height of the mercurial column, nor its variations, with sufficient accuracy to be of the slightest use for any philosophical purpose whatever. Even as a weather-glass, it is the worst of all the common forms of the barometer.

Sir Samuel Moreland proposed to enlarge the scale, by inclining the upper part of the tube so as to form a considerable angle with the perpendicular. By this contrivance the scale is increased in the proportion of radius to the cosine of the angle of inclination; but the friction on the sides of the tube is greatly increased, and it is very difficult to determine the exact plane of the top of the column which requires to be read off on a vertical scale. This construction is easily conceived without a diagram.

We shall notice two other forms of the barometer, proposed with a different view from that of enlarging the scale. Fig. 4, is a modification of the siphon barometer proposed by Gay Lussac. It differs from the common form in this respect, that, after the tube has been filled, the short branch is hermetically closed at the top, and the communication with the atmosphere takes place through a small capillary hole drilled laterally through the tube at *o*, so fine that though it admits the air to pass freely, it prevents the passage of the mercury. The barometer is thus rendered very convenient for carriage; but notwithstanding the promising appearance of this barometer, it has been found, particularly in travelling, that a portion of air will frequently insinuate itself through the mercury. In order to prevent the possibility of the accident, an ingenious modification has been made by M. Bunten, a Parisian artist. It consists in causing the part of the tube *a b* to terminate in a very fine point, and to penetrate to some depth into the other part *c o*, to which it is joined at *c*, in the manner represented in Fig. 5. Now if an air bubble from the end *o*, which communicates with the atmosphere, should find its way through the bent capillary tube, it will pass along the sides of the bulging part, and instead of penetrating to the vacuum at *a*, will be arrested at *c*, whence it is easily expelled by reversing the barometer.

None of the contrivances which have been described for increasing the range of the oscillations have been found to succeed well in practice. It is found to be decidedly better to apply minute divisions, than to attempt to enlarge the scale; accordingly, experimenters now adhere to one or other of the two ancient forms, the cistern barometer and the siphon barometer. The height of the column in the siphon barometer is conveniently measured by means of a movable scale attached to the frame which supports the tube; by means of a tangent screw, the scale is raised or lowered till its zero coincides exactly with the surface of the mercury in the lower branch; and with the assistance of a vernier, the height can be read off to the hundredth or two-hundredth of an inch with sufficient precision. The scale of the cistern barometer is usually fixed, and the bottom of the cistern is raised or lowered by a screw till the surface of the mercury in it coincides with the zero of the scale; but the scale may be movable, and its zero brought to coincide with the surface of the mercury in the basin, as in the former case. In order to determine when this coincidence takes place, various expedients may be had recourse to. The most usual is to place on the surface of the mercury a float carrying a vertical needle, some point on which answers to a fixed point on the scale, and the coincidence obtains when the two points are brought into the same level. Another contrivance to effect the same purpose was employed by Fortin, a celebrated French artist. An ivory needle is attached to the scale, pointing downwards, and having its point exactly in the same level with the zero of the scale. The image of the needle is clearly reflected from the surface of the mercury in the cistern, and the cistern is raised or lowered till the point of the needle and its image precisely coincide.

In order to construct a good barometer, it is indispensably necessary that the mercury be perfectly free from impurities, and carefully purged of air; this is obtained by boiling it. The particles of air and moisture which cling obstinately to the sides of the tube must also be expelled by heat; the mercury must then be introduced slowly and continuously in a hot state, and while the tube continues hot. Since the time of Deluc it has been usual to boil the mercury in the tube before inverting it and forming the vacuum; but doubts now begin to be entertained among the most skilful makers of the expediency of this very troublesome process. The mercury is partially oxydated by boiling, and a thin crust formed, which keeps the column suspended at a greater height, and obstructs the freedom of the motion. It is important that the diameter of the tube be not very small; for it is found that the mercury moves with more freedom in a tube of considerable width, the oscillations following the atmospheric changes with more promptitude than in one of smaller dimensions; besides which, there is less disturbance from capillary attraction. The interior diameter should in every case exceed one-fourth of an inch.

The value of the barometer as a scientific instrument depends on the purity of the mercury, and the total exclusion of atmospheric air. By proper care in the construction, it is, perhaps, possible to expel every particle of air from the mercury and the interior of the tube when the barometer is made; but it seems doubtful if, by any means whatever, it can be preserved for a considerable length of time in this state. The most carefully constructed barometers are liable to a slow and gradual deterioration by the intrusion of air, which has been supposed to insinuate itself between the metal and the tube, and not through the mercury. To obviate this inconvenience Professor Daniell conceived the ingenious idea of fixing to the open end of the tube of the cistern barometer a substance having a greater affinity than glass for mercury. "I caused," says he, "a small thin piece of platinum tube to be made, about the third of an inch in length, and of the diameter of the glass tube; this was carefully welded to its open end, so that the barometer tube terminated in a ring of platinum. The tube was filled and boiled as usual, and the infiltration of air was completely prevented by the adhesion of the mercury both to the interior and exterior surface of the platinum guard. I have no doubt that a mere ring of wire welded, or even cemented, upon the exterior surface of the glass, which would be a much easier and less expensive operation, would be a sufficient protection, as the slightest line of perfect contact must effectually arrest the passage of the air"

In all barometic observations there are, in general, two essential corrections to be made; one for the capillarity or depression of the mercury in the tube, and the other for temperature. Pure mercury in a glass tube always assumes a convex surface. The following are the corrections for tubes of different diameters, according to the theory of Mr. Ivory.

Diam. of Tube. *Inches.*	Depression. *Inches.*	Diam. of Tube. *Inches.*	Depression. *Inches.*
·10	·1403.	·40	·0153.
·15	·0868.	·45	·0112.
·20	·0581.	·50	·0083.
·25	·0407.	·60	·0044.
·30	·0292.	·70	·0023.
·35	·0211.	·80	·0012.

These corrections, which must always be applied to cistern barometers, show that wide tubes ought to be preferred; in fact, when the diameter of the tube exceeds half an inch, they may be safely omitted. In siphon barometers having both branches of the same diameter, the depression is equal at both ends; consequently the effect is destroyed, and no correction is required. This is a considerable advantage; for notwithstanding the most elaborate calculations, some uncertainty must always remain with regard to the exact amount of the capillary repulsion.

The correction for the temperature, which is the most important, depends on the expansion of the mercury, and the expansion of the scale on which the divisions are marked. If we make $a =$ the height of the thermometer in degrees above the freezing point, $x =$ the fractional part of its bulk which mercury expands for one degree of heat on Fahrenheit's scale, $y =$ the fractional part of its length by which the scale increases, $h =$ the observed height of the barometer; then the height which would have been observed had the thermometer stood at the freezing point is

$$h - h\,a\,(x - y).$$

The expansion of mercury in part of its bulk is ·0001001. The scale is generally of some mixed metal of which the expansion is not very well ascertained: supposing it to be equal to that of copper, the expansion would be ·0000096; therefore it will be sufficiently accurate to neglect the temperature of the scale, and assume that of the mercury to be ·0001. Hence the following practical rule for reducing an observed height to the corresponding height at the temperature of the freezing point: "Subtract the ten-thousandth part of the observed altitude for every degree of Fahrenheit above 32." Suppose the thermometer 54° and the barometer 30 inches, the correction will be $(54-32) \times 30 \times \cdot 0001 = \cdot 066$, to be subtracted from 30 inches. In order to find the value of this correction a thermometer must be attached to the barometer, and observed at the same time. A table, showing the correction for temperature for every degree of Fahrenheit from 30° to 90°, and for every difference of half an inch in the height of the mercury from 28 to 30·5 inches, was constructed by Professor Schumacher, and is given by Mr. Baily in the *Phil. Trans.* for 1837.

Cause of the variations of the barometer.—Various theories have been proposed to account for those frequent atmospherical changes which cause the rise and fall of the barometer, but none of them can be regarded as very satisfactory. Whatever tends to increase or diminish the vertical pressure will obviously cause the barometer to rise or fall; but the vertical pressure may be increased either by an influx of winds and the accumulation of air at any place, or by a diminution of the elasticity of the atmosphere. The presence of heat or of moisture augments the elasticity, and consequently reduces the weight of the vertical column. During the prevalence of northerly and easterly winds the barometer stands high, the elasticity being diminished by the cold. But the real difficulty, Professor Leslie remarks, "consists in explaining why the variations of the barometer should be greater in the high latitudes than between the tropics, and why they should exceed in all cases the quantities which calculation might assign. The only mode, perhaps, of removing the difficulty is to take into consideration the comparative slowness with which any force is propagated through the vast body of the atmosphere. An inequality may continue to accumulate in one spot before the counterbalancing influence of the distant portions of the ærial influence can arrive to modify the result. In the higher latitudes, the narrow circle of air may be considered as in some measure insulated from the expanded ocean of atmosphere; and hence, perhaps, the variations of the barometer are concentrated there, and swelled beyond the due proportion."

Uses of the barometer.—The barometer is an instrument of great importance in astronomy, its indications forming an essential element in determining the amount of atmospheric refraction. It is also, on account of its application to the measurement of altitudes, indispensable in all researches connected with the climate. The purpose for which it is most commonly sought after, is to prognosticate the state of the weather. On land this is perhaps the least important of its applications, but the case is widely different at sea.

No certain rules can be laid down for prognosticating the state of the weather from the barometer. The following are probably of as general application as any that can be given. It is always to be remembered that what the barometer actually shows is the present pressure of the atmosphere: and that its variations correspond to atmospherical changes which have already taken place, the effects of which may follow their cause at a greater or less interval.

1. After a continuance of dry weather, if the barometer begins to fall slowly and steadily, rain will certainly ensue; but if the fine weather has been of long duration, the mercury may fall for two or three days before any perceptible change takes place, and the longer time elapses before the rain comes, the longer the wet weather is likely to last.

2. Conversely, if after a great deal of wet weather, with the barometer below its mean height, the mercury begins to rise steadily and slowly, fine weather will come, though two or three wet days may first elapse; and the fine weather will be more permanent in proportion to the length of time that passes before the perceptible change takes place.

3. On either of the two foregoing suppositions, if the change immediately ensues on the motion of the mercury, the change will not be permanent.

4. If the barometer rise slowly and steadily for two days together or more, fine weather will come, though for those two days it may rain incessantly, and the reverse; but if the barometer rise for two days or more during rain, and then on the appearance of fine weather begins to fall again, that fine weather will be very transient, and *vice versa*.

5. A sudden fall of the barometer in the spring or autumn indicates wind; in the summer, during very hot weather, a thunderstorm may be expected; in winter, a sudden fall after frost of some continuance indicates a change of wind, with thaw and rain; but in a continued frost, a rise of the mercury indicates approaching snow.

6. No rapid fluctuations of the barometer are to be interpreted as indicating either dry or wet weather of any continuance; it is only the slow, steady, and continued rise or fall that is to be attended to in this respect.

7. A rise of the mercury late in the autumn, after a long continuance of wet and windy weather, generally indicates a change of wind to the northern quarters, and the approach of frost.

BARYTO CALCITE. A mineral occurring both massive and crystallized in oblique rhombic prisms. It contains 66 per cent. of carbonate baryta and 34 per cent. of carbonate of lime.

BASALT. A common species of trap. Essentially composed of felspar and augite, of a compact texture, and dark-green gray or black color; often found crystallized in pentagonal or six-sided figures, as those in the Giants' Causeway and the Island of Staffa are magnificent examples. The Palisades on the Hudson river are of basalt.

BASE. In chemistry the substance with which an acid is combined: thus in the sulphate of iron, iron is the base united with sulphuric acid. Almost all oxides of metals are bases.

BASSORINE. A modification of gum, originally found by Vauquelin in *gum bassora*. It is semi-transparent, and forms a thick mucilage with water without dissolving: an addition of a little nitric or muriatic acid aids its solubility very much.

BATTEN. Wooden scantling from two to six inches broad, and from one to two inches thick, used in walls to secure the laths over which the plaster is laid.

BAY SALT. A large grained salt obtained by the spontaneous evaporation of sea water in large shallow pits exposed to the full action of sun and air.

BDELLIUM. An African gum resin of a dark brown color: common in samples of myrrh.

BEAM. A horizontal piece of timber used for resisting the strain of a weight; as a tie-beam, which acts like a string or chain by its tension; a straining-piece where it acts by compression; or a bressummer where it bears a resisting weight.

BEER. Wine made from grain, chiefly by fermenting an infusion of barley, malt, and of hops, and bears different names according to the color and the strength. Wheat and maize are susceptible of undergoing a like change with barley. Oats and rice also are capable of producing beer; and many other vegetable bitters are substituted for the hop. The objects in view in this manufacture are to form sugar, and consequently the alcoholic portion of the liquor, the other to communicate a particular flavor, and assist in its preservation. The first stage is to convert the barley into malt, by making the grain germinate up to a certain point, when a peculiar azotized substance called *diastase* is formed, which possesses the remarkable property of converting the starch into a fermentible sugar, resembling grape-sugar. This change does not take place at once, for the starch is first changed into a gummy mucilaginous substance called *dextrin*. This substance does not ferment on the addition of yeast; but by the action of diastase it is readily converted into starch-sugar, which is fermentible. This is generally a distinct operation from that of brewing, and consists of four processes, namely, *steeping*, *couching*, *flooring*, *and kiln-drying*. In steeping, the malt is placed in sunk cisterns, sprinkled with water so as barely to cover it, and let lie for about 40 hours. The barley imbibes moisture and increases in bulk; it gives out carbonic acid, which dissolves in the water; some of the husk colors the water also. The grain becomes whiter and so soft that the two ends of a grain can be squeezed between the finger and thumb; the water is then drained off; it is then heaped or *couched*. When it warms and begins to germinate, the grain absorbs oxygen and gives out carbonic acid, and the temperature rises to 90°.

The germination of the malt is now stopped by drying on a kiln, which consists of a chamber, floored with an iron plate, full of holes, and furnished with a vent in the roof for the escape of fumes. Below this floor is a furnace containing charcoal or coke, the heat of which ascends through the malt.

Pale amber and brown malt can be produced from the same kind of malt, by varying the temperature of the drying. Pale malt is dried at the proper temperature, and produces the best beer; the other varieties are scorched and charred. The brown malt gives a bitter taste, and being less alcoholic, became a more favorite drink with the laboring classes of London: and hence its name "porter." The malt is then ground or crushed into coarse powder, and then passed into a mash tun containing water heated up to 170°. Here it digests on the malt till all the sugar is extracted, when the liquor, now called worts, is drawn off. The grain receives three waters, which, when drawn off, are mixed together. The first wort is sometimes set aside for superior ales, and the second and third for inferior beers. The malster regulates the strength of his worts by an instrument called the *saccharometer*, a variety of *hydrometer*.

The worts are next concentrated by boiling, and cleared of the vegetable albumon which coagulates. The hops are added in this vessel, and are kept stirred, so as not to lie on the bottom. The quantity of hops added depends on the quality of the beer, the season, and climate to which it may be exported. In warm weather a larger portion is added. In strong English beer 4¼ lbs. of hops is allowed for a quarter of malt: for ale and porter 1 lb. of hops to a bushel of malt. The boiling being completed, the liquid is now cooled suddenly. It is then passed into the fermenting tun, and yeast added. One gallon of yeast generally sets 100 gallons of wort in active fermentation;

by this latter action the sugar is changed into alcohol. Before this is fully completed the worts are racked off into large hogsheads, with the bungholes open, where fermentation is allowed to complete itself. By this means no vinegar is produced, which would be the case were the process to be completed in open vessels. The fermentation over, the beer is pumped up into store-vats of great size, where it is kept until required to be drawn off for consumption. The casks are bunged down tightly. The beer cleanses itself in these vats, throwing down a scum of flocculent matter. Isinglass, or *finings*, is sometimes added for this purpose, to expedite the clarification.

BEET. The sweet succulent root of *Beta vulgaris*, a Chenopodiaceous plant of biennial duration. It is used in the winter as a salad, for which purpose the red and yellow beets of Castelnaudari are the best; for the food of cattle, under the name of mangel-wurzel; and for the extraction of sugar: for the last object a white-rooted variety with a purple crown is the most esteemed. Sea beet, *Beta maritima*, is a well known and excellent substitute for spinach.

To Napoleon is due the merit of having established the extraction of sugar from beet as a branch of manufacture, which is now in so flourishing a condition in France as to gradually exclude the Colonial sugar in the French market. Its manufacture was twice attempted in Ireland with such success, that the West India planters had their jealousy aroused: and their influence was such, that a heavy prohibitory duty was laid on beet sugar, which crushed the trade; it is now, however, removed, and the manufacture of sugar from beet, will, in a few years, in temperate latitudes, exclude that of the cane and the maple. (For a description of the process, *see* SUGAR.)

BELL METAL. An alloy of 80 parts of copper and 20 of tin. The Indian gong metal is a similar alloy. An English bell metal analyzed by Dr. Thomson was found to consist of 800 copper, 101 tin, 56 zinc, and 43 lead. Small shrill bells generally contain zinc.

BELLOWS. A machine contrived to propel air through a tube or orifice. It is used for blowing fires, supplying the pipes of organs, and other purposes, and is constructed according to various forms; but the principle is the same in all of them. The dimensions of a space in which air is confined are contracted: the air being permitted to escape only at a small opening, rushes out with a velocity proportional to the pressure and to the smallness of the opening. (For improved bellows and blowing machines, *see* METALLURGY.)

BEN NUTS. The seeds of an Arabian plant called *moringa aptera*; they yield an oil called oil of ben, and have been employed in syphilitic diseases.

BEN, OIL OF. The expressed oil of the nut of the *moringa aptera*. This oil is remarkable for not becoming rancid by age; and as it is perfectly insipid and inodorous, it is used for extracting the fragrancy of certain flowers, such as jessamin, orange, &c. The same tree furnishes the *lignum nephriticum*, supposed to be useful in certain affections of the kidneys.

BENGAL STRIPES. Ginghams, a cotton fabric woven with colored stripes.

BENZOIC ACID. A constituent of many balsams, generally obtained by heating benzoin upon a shallow iron pan, surmounted by a frame capped with cartridge paper, upon which the acid sublimes at a gentle heat. It may also be obtained by boiling benzoin with slaked lime, and decomposing the newly-formed benzoate of lime by hydrochloric acid; it is in either case obtained in white crystalline plates. Its chemical composition is $C^{14} H^5 O^3$, and is classed as the oxide of a supposed radical benzule. Benzoic acid melts at 212°, dissolves in 200 parts of cold and 25 parts of boiling water, in twice its weight of alcohol, and freely in ether, fats, and volatile oils. It is an ingredient of fumigating powders and pastiles. It enters into the composition of Friar's balsam, a veterinary medicine, and of the cosmetic *virgin's milk*, made of two drachms of the alcoholic solution of benzoin with one pint of rose water.

BENZOIN. The resinous exudation of the *styrax benzoin*, a tree which is a native of Sumatra. Benzoin is a combination of resin and *benzoic acid*. It has a mottled or amygdaloid texture, and is composed of a mixture of brown and white parts. It has a fragrant odor, and is much used in perfumery and varnishes.

BERBEREN. A yellow bitter principle, contained in the alcoholic extract of the root of the barberry tree.

BERBERRY. (Lat. *berberis.*) A spiny shrubby plant, bearing yellow flowers, and succulent one-celled fruit growing in racemes. It is one of a genus in which the fruit is universally fleshy and acid, although often less so than in the common kind (*berberis vulgaris.*) Some of the species have pinnated leaves, many are evergreens, and several have a black fruit; even the common sort has a variety of this description, as well as others with pale yellow and stoneless fruit. There is an idea among people in the country, that a berberry bush brings blight to a wheat field; but the parasitical fungus which attacks the berberry is altogether different from that which produces the mildew of wheat, which cannot possibly be communicated by the one to the other. It gives a yellow dye to leather.

BERGAMOT, ESSENCE OF. The essential oil of the rind of a small pear-shaped fruit, the produce of the *citrus limetta bergamium.* It is much used as a perfume, and apt to be adulterated with the oils of orange and lemon peel, and with alcohol.

BEVEL. In architecture, an instrument for taking angles. One side of a solid body is said to be bevelled with respect to another when the angle contained between their two sides is greater or less than a right angle.

BEVEL ANGLE. A term used among artificers to denote an angle which is neither a right angle nor half a right angle.

BEVEL GEER. In mechanics, a species of wheelwork, in which the axles of two wheels working into each other are neither parallel nor perpendicular, but inclined to one another in a certain angle. Wheels of this kind are also called conical wheels, because their teeth may be regarded as cut in the frustrum of a cone.

BILE. A fluid secreted in the liver, of a yellow color, and a nauseous taste, compounded of sweet and bitter; it sinks in water, and mixes with it in all proportions; it is slightly alkaline, and feels soapy. It contains a peculiar bitter principle, which has been called *picromel*, and a little free soda and saline matters. According to Berzelius, the solid constituents of bile amount to about one-tenth of its weight.

Modern chemistry regards bile as a *soda soap*, and on this account *ox gall* or bile is used by water-color painters and scourers of cloth, but it requires to be freed from its green color: this is accomplished by letting it settle, and then evaporating it in a water bath to thickness, and letting it dry into thin cakes. A little alum added to a solution of gall, removes the color after lying together for three months. Prepared gall gives solidity to colors and paints, either by being mixed with them, or passed over them on papaper. Mixed with gum it thickens the colors, prevents the gum cracking and the colors from running into each other. It heightens the tint of carmine, ultramarine, green, and the most delicate colors, and spreads them smoothly on ivory and paper. Coated over black lead or crayon drawing, it keeps them from being rubbed off; removes grease spots from ivory, paper, and cloth; and a small portion added to ink, renders it fluid.

BINNACLE. The case or stand in which the steering compass is placed; it is fixed near the tiller or wheel. At night the compass is illuminated by a lamp placed over it.

BINOCLE, or BINOCULAR TELESCOPE. A telescope to which both eyes may be applied at once, and in which, consequently, an object may be observed with both eyes at the same time.

BIRDLIME. A glutinous substance extracted by boiling the bark of the holly tree: a similar substance may be obtained from misletoe, from the young shoots of elder, and some other plants. It is much used in India for destroying insects. It contains resin, mucilage, free acid, and coloring matter.

BISCUIT. In sculpture, a species of porcelain, of which groups and figures in miniature are formed, which are twice passed through the furnace or oven. It is executed without glaze upon it. In pottery, this term is applied to earthenware and porcelain, after it has been hardened in the fire, and before it receives the glaze: in this state it is permeable to water. On which account it is now largely used as porous cells for electrotype purposes.

Biscuit. An unfermented bread, which, when well prepared, may be kept for a long time; and hence valuable as a common form of bread at sea. In England, the sea biscuit manufacture by hand for government-contract has been suspended by the machinery invented by T. T. Grant, Esq., of the Royal Clarence yard, which is this: the meal or flour is conveyed into a hollow cylinder four or five feet long and about three feet in diameter, and the water, the quantity of which is regulated by a gauge, is admitted to it; a shaft, armed with long knives, works rapidly round in the cylinder with such astonishing effect, that in the short space of three minutes, 340 lbs. of dough are produced, infinitely better made than that mixed by the naked arms of a man. The dough is removed from the cylinder and placed under the breaking-rollers; these latter, which perform the office of kneading, are two in number, and weigh 15 cwt. each; they are rolled to and fro over the surface of the dough by means of machinery, and in five minutes the dough is perfectly kneaded. The sheet of dough, which is about two inches thick, is then cut into pieces half a yard square, which pass under a second set of rollers, by which each piece is extended to the size of six feet by three, and reduced to the proper thickness for biscuits. The sheet of dough is now to be cut up into biscuits, and no part of the operation is more beautiful than the mode by which it is accomplished. The dough is brought under a stamping or cutting-out press, similar in effect, but not in detail, to that by which circular pieces for coins are cut out of a sheet of metal. A series of sharp knives are so arranged that, by one movement, they cut out of a piece of dough a yard square about sixty hexagonal biscuits. The reason for a hexagonal (six-sided) shape is, that not a particle of waste is thereby occasioned, as the sides of the hexagonals accurately fit into those of the adjoining biscuits; whereas circular pieces cut out of a large surface always leave vacant spaces between. That a flat sheet can be divided into hexagonal pieces without any waste of material is obvious.

Each biscuit is stamped with the queen's mark, as well as punctured with holes, by the same movement which cuts it out of the piece of dough. The hexagonal cutters do not sever the biscuits completely asunder; so that a whole sheet of them can be put into the oven at once on a large peel or shovel adapted for the purpose. About fifteen minutes are sufficient to bake them; they are then withdrawn and broken asunder by the hand.

The corn for the biscuits is purchased at the markets, and cleaned, ground, and dressed at the government mills. In quality it is a mixture of fine flour and middlings, the bran and pollard being removed. The ovens for baking are formed of fire-brick and tile, with an area of about 160 feet. About 112 lbs. weight of biscuits are put into the ovens at once. This is called a suit, and is reduced to about 110 lbs. by the baking. From twelve to sixteen suits can be baked in each oven every day, or after the rate of 224 lbs. per hour. The men engaged are dressed in clean check shirts and white linen trowsers, apron, and cap; and every endeavor is made to observe the most scrupulous cleanliness: 450 lbs. of dough may be mixed by the machine in four minutes, and kneaded in five or six minutes; we need hardly say how much quicker this is than men's hands could effect it. The biscuits are cut out and stamped sixty at a time, instead of singly: besides the time thus saved, the biscuits become more equally baked, by the oven being more speedily filled. The nine ovens at Gosport used to employ 45 men to produce about 1,500 lbs. of biscuit per hour; 16 men and boys will now produce, by the same number of ovens, 2,240 lbs. of biscuit (one ton) per hour.

The comparative expense is thus stated: Under the old system, wages, and wear and tear of utensils, cost about 1*s.* 6*d.* per cwt. of biscuit: under the new system, the cost is 5*d.* British money.

BISMUTH. A brittle, yellowish-white metal, of crystalline texture. Its specific gravity is 10; it fuses at 476°, and at a red heat it sublimes in close vessels. It conducts heat less perfectly than most of the other metals. When strongly heated it burns with a bluish white flame, and is rapidly oxidized. Its equivalent upon the hydrogen scale is 71; and it forms only one salifiable oxide, the equivalent of which is 79. When nitrate of bismuth is dropped into water, a white powder is thrown down, formerly called *magistery of bismuth* or *pearl white*: it is a subnitrate. This is used as a cosmetic. A brown *peroxide of bismuth* is obtained by fusing the protoxide with caustic potash. Some of the alloys of bismuth are remarkable for their fusibility: a compound of 8 parts of bismuth, 5 of lead, and 3 of tin, melts in boiling water, and is commonly called *fusible metal*. The ores of bismuth are not common; but it occurs *native*, and combined with oxygen, sulphur, and arsenic. The Germans call it *wismuth*.

Bismuth, alloyed with lead and tin, has been used as the patent safety plug in steam boilers to guard against explosion. It was supposed that at a high temperature, the alloy would melt and allow the steam to blow itself out. This has not been found the case, for this alloy, when exposed a long time to the action of steam, undergoes a process of change by which the more fusible alloy is melted out, and what remains is so hard as not to fuse: after the explosion of boilers, these plugs have been found unmelted.

Fusible metal has been used for casts for anatomical preparations, casts from medals, and even the surfaces of wood and paper. Cake moulds for toilet soap manufacture, are made of this metal.

BITTERN. The mother liquor or uncrystallized residuum of *salt works*, so called on account of its bitter taste. Chloride of magnesium and sulphate of magnesia, are its chief ingredients.

BLACK LEAD. (*See* PLUMBAGO.)

BLACK PIGMENT. A fine lampblack, obtained in England by burning a thick jet of coal gas with a small quantity of air, by which its carbon is deposited very fine. In this country it is made by the combustion of oil and of rosin, carried on incompletely. This fine and light black is used in the manufacture of the better quality of printing ink.

BLACKING. An article prepared in various ways for polishing shoes and boots. Each manufacturer has his own recipe, in which ivory black or some other black color, oil, and vinegar, with molasses, are the principal ingredients. The following is the mode of making the waterproof or India-rubber blacking:

18 ounces of caoutchouc are to be dissolved in about 9 pounds of hot rape oil. To this solution 60 pounds of fine ivory black and 45 pounds of molasses are to be added, along with 1 pound of finely-ground gum arabic, previously dissolved in 20 gallons of vinegar, of strength No. 24. These mixed ingredients are to be finely triturated in a paint-mill till the mixture becomes perfectly smooth. To this varnish 12 pounds of sulphuric acid are to be now added in small successive quantities, with powerful stirring for half an hour. The blacking thus compounded is allowed to stand for fourteen days, it being stirred half an hour daily; at the end of which time, 8 pounds of finely ground gum arabic are added, after which the stirring is repeated half an hour every day for fourteen days longer, when the liquid blacking is ready for use.

In making the paste blacking, the above quantity of India-rubber, oil, ivory black, molasses, and gum arabic, may be used, the latter being dissolved in only 12 pounds of vinegar. These ingredients are to be well mixed, and then ground together in a mill till they form a perfectly smooth paste. To this paste 12 pounds of sulphuric acid are to be added in small quantities at a time, with powerful stirring, which is to be continued for half an hour after the last portion of the acid has been introduced. This paste will be found fit for use in about seven days.

BLANKET. (*See* WOOLLENS.)

BLAST FURNACE. (*See* IRON.)

BLEACHING. The art of depriving stuffs and goods of the coloring matters contained within their texture, whether natural or artificial.

When calico, muslin, or other cotton fabrics have been spun and woven, they generally pass into one or other of these establishments before being brought to market. If they are to be sold in the white state, they require *bleaching;* if in a colored state, they require *dyeing;* if in a decorated or ornamented state, they require *printing;* and hence it arises that there are in one establishment or congregated together, *bleach-works*, *dye-works*, and *print-works*. As, however, a well-printed piece of cotton requires to be bleached and dyed as well as printed, the print-works have, in most cases, the means for carrying on the bleaching and dyeing as well as the printing processes; and there are thus facilities for witnessing all three operations in one establishment. Most of these works are situated in the valleys (when not worked by steam-power), in order to have a supply of water from the streams which flow through them.

Bleaching is now a very different process from what it was in the last century. At that time it required a period of several months to bleach a piece of cloth, and this, too, only in the summer time. In some cases the cloth was sent in the spring of the year to Holland, to be bleached on the level grassy plains of that country, and returned in the autumn; while in other cases, when bleached in the English fields, there was so much depredation as to lead to an unhappy system of severe laws and general distrust. Chemists were thence led to inquire whether means might not be adopted more expeditious than that of exposure to the open air of a bleach-ground. Home, Scheele, Berthollet, and Henry, made successive steps in this direction, and paved the way for the introduction of the use of *bleaching-powder*, by Mr. Tennant, about the year 1800. From that date the present most efficient system of bleaching has been followed in the great works of the north, modified occasionally in the minor details.

Most large bleach-works exhibit a considerable range of buildings, comprising a *croft* or bleach-house, a dye-house, reservoirs and water-filters, and subsidiary buildings. The supply of water required in bleaching and dyeing is enormous, and extensive arrangements are necessary for the filtering of the water before using, since the success of the process very much depends on the purtiy of the water.

Matters are then ready for the bleaching process. The *croft* (so named probably because it renders the same service as the croft or bleaching-ground under the old system). is generally a large stone-floored building, filled with coppers and vessels of various kinds, abundantly supplied with water, and not often free from clouds of steam. Here successive washings, boilings, and steepings bring the cotton to a white state. In the first place the singed cloth, which has acquired a kind of nankeen colour, is further sewn up, until five hundred pieces are connected together, end to end; that is, there are $500 \times 28 = 14,000$ yards, or eight miles of cloth in one continuous piece. This enormous piece passes into a *washing-engine*, to cleanse it from the "dressing" or mucilage which the weaver had introduced into his warp. The engine contains an abundant and constantly renewing supply of water; and the cloth is wound spirally round a kind of beam above it, hanging in the water in a succession of bends or curvatures. The cloth travels onwards, and in so doing passes twenty times through the water beneath, every part of it ascending and descending twenty times before it leaves the machine. About two hundred and fifty yards are thus washed per minute; and the paste which is washed from the cloth is carried away by a pipe.

As the cloth leaves the washing-machine, it is taken by one or two men and folded backward and forward till the whole connected piece forms a cube of five or six feet. From this heap it is again removed to undergo the process of "liming." The cloth passes into a kind of boiler called a "keir," where it is exposed for eight or ten hours to the action of a solution of lime, 40 lbs. of lime being used for the eight miles of cloth. In this keir or vessel the hot liquor is brought up a central tube in such a manner, that, being echoed or reflected from a concave surface above, it falls down on the cloth in a profuse shower, thus acting equally on the whole of the cloth. The cloth is next subjected to a second washing, to remove the lime which may be retained by its fibres. Then ensues the process of "grey souring," in which the cloth passes through a machine similar to the washing-machine, but containing very dilute sulphuric acid instead of water; and after this there is a third washing in the machine, to remove all the adherent acid. After this comes the "first ashing." Twenty-four miles of cloth (the real extent of these operations, as conducted at the present day in large establishments, will be better appreciated thus than by speaking of 1500 pieces), are put into a keir, or cast-iron boiler, and exposed for sixteen hours to the action of a boiling-hot solution of soda: this constitutes the "ashing." Then for a fourth time the cloth is washed, preparatory to the process named "chemicking." A weak solution of bleaching-powder, or chloride of lime, is put into a machine something like the washing-machine, and the cloth is passed through it. After lying wet in the heap for six or eight hours, to allow the "chemick" to act on the fibres, the cloth goes through the process of "second souring" in weak sulphuric acid, somewhat as before. It is then washed for a fifth time in the machine, to which succeeds the "second ashing;" then a sixth washing, then a "second chemicking," then a "third souring," and then a seventh washing. It will thus be seen that there is a succession of processes following in a certain order; the three agents,—sulphuric acid, soda, and bleaching-powder,—being separately applied, each more than once, and the cloth being washed in clean water after every such application. So powerful is the bleaching-agent, that 7 lbs. of chloride of lime are said to suffice for the bleaching of 500 pieces of cloth. The machines here described are a late improvement: for until recently the cloth was dipped in tanks to be "soured" and "chemicked," and thence hauled up by poles.

After a process of "hot-watering" and squeezing, the cloth leaves the croft, and passes into a room where boys and girls rip or pick the pieces asunder, so that each piece of twenty-eight yards becomes again separated from the others. Each piece is folded into a flat square mass, and men beat these masses against the edge of a stone in a peculiar manner, for the purpose of removing creases from the cloth. The cloth is then hung up on wooden bars in a drying-room, which is heated to a high temperature by steam-pipes near the floor. Finally, the bleached cloth, which now presents a whiteness of the utmost purity, is brought into the warehouse, sorted, and tied up into parcels of ten pieces each.

Such is a brief sketch of the process of bleaching cotton; and whether we notice it in connexion with dyeing and printing, or take the instance of a bleachery independent of them, the preceding details will equally serve to convey a general idea of this important process.

The colour of manufactured wool depends partly upon its own oil, and partly upon the applications made to it in the loom. These are got rid of in the fulling mill by the joint action of fullers' earth and soap; the cloth is then well washed and dried, and is tolerably white; if the slight yellow tint which it retains is objectionable, it is prevented by adding a little stone-blue to the washing water, or by exposure to the fumes of burning sulphur; this latter method, however, gives it a harsh feel, and if afterwards soaped, its yellowishness returns.

The colour of raw silk depends upon a natural yellow varnish, which is got rid of by boiling it in white soap and water, and by repeated rincings. Certain articles of wove cotton, such as stockings, are bleached as usual, and finished by the action of *sulphurous acid*, or the fumes of burning sulphur. Straw is also whitened by a similar operation; and hence bleached straw hats are apt to have a disagreeable sulphurous smell.

BLEACHING POWDER. Chloride of lime, made by exposing slaked lime to the action of chlorine. The best samples do not contain more than 30 per cent. of chlorine; it varies greatly in strength. Professor Graham's test is simple in practice, and depends on the effect of the chlorine of the bleaching powder in peroxidizing the proto-salt of iron, of which two equivalents require one of chlorine. The chlorine acts by decomposing water, and liberating a corresponding quantity of oxygen.

BLENDE. Native sulphuret of zinc.

BLOCK. (Teutonic.) In architecture, a large unworked mass of marble or other stone. It is also vulgarly used to denote a modillion in a cornice.

Block. In navigation, the case that contains the wheel or *sheeve* of the pulley (which last term is not used at sea.) Two or more blocks, with the rope, constitute a *tackle* (pronounced tăcle.) Blocks are also the pieces of wood and iron on which, piled up, the ship's keel is supported when she is in dock.

BLOCK TIN. Tin cast into blocks or ingots. It is generally less pure than grain tin.

BLOOD. The fluid which circulates in the heart and blood-vessels. When viewed under the microscope it appears to consist of very minute *red globules*, or spheroids, floating in a colourless fluid. The average quantity in an adult man is estimated at about 28 lbs.; it is of two distinct colours in the arterial and venous systems,—florid red approaching to scarlet in the former, and dark crimson in the latter. Its specific gravity is between 1·050 and 1·070. When drawn from its vessels it gelatinizes or coagulates in the course of a few minutes of common temperature, and soon separates spontaneously into *serum* and *coagulum*. The serum is a yellowish soapy-feeling fluid, of the specific gravity of about 1·030. It exhibits a slight alkaline reaction upon test papers; when heated it becomes opaque, and at 156° it coagulates. It is also coagulated by alcohol, and by most of the acids; acetic acid and ether do not coagulate it; solutions of corrosive sublimate, of subacetate of lead, and of chloride platinum, occasion precipitates in it, even when considerably diluted with water. These properties of serum are dependent upon the presence of a peculiar proximate animal principle called *albumen;* the same substance, and with very nearly the same properties, constitutes the *white of egg*, the coagulability of which by heat is well known. Besides the above there is another most delicate test of albumen in solution, which consists in adding to the liquid suspected to contain it a little strong *acetic acid*, and afterwards a few drops of *ferrocyanate of potash*. If albumen be present, a white cloud is produced. This is even a more accurate test than corrosive sublimate. White of egg is coagulated by ether, while serum is not. According to Marcet, 1000 parts of serum of human blood are composed of water 900, albumen, 86·8, muriates of potassa and soda 6·6, muco-extractive 4, carbonate of soda 1·65, sulphate of potassa 0·35, earth phosphates 0·60.

The coagulum of the blood is of a more or less firm texture, and has a greater specific gravity than the serum. It contains the coloring particles of the blood; and when carefully washed, these are carried out of it, and a tenacious whitish matter remains, which has been termed *fibrine*, but which, in all essential points, has the properties of coagulated albumen.

The coloring matter of the blood, *hæmatosine*, may be obtained by evaporating its aqueous solution at a temperature below 100°; it then appears almost black, but resumes its red color when dissolved in water. It is soluble in acids and in alkalies. These solutions are dark-colored; but when mixed, so as to become *neutral*, the hæmatosine falls of a bright red color. Accordingly, when the clot of blood is put into acids it becomes brown or blackish, and is very similarly discolored by alkalies; but most neutral salts render it florid.

The chief use of blood is as a manure made into a compost of 50 gallons of blood with a quarter of peat-ashes and charcoal powder; on light soils, 48 bushels have been laid on each acre, or half a hundred weight with twelve tons of farm dung. It is now rarely used in sugar refining. It is used to make animal charcoal in Prussian blue works, and also in some Turkey-red dye works.

BLOW-PIPE. An instrument for directing a small jet of air laterally into the flame of a candle or lamp, so that a portion of the flame is formed into a long slender cone in the direction of the jet, the heat of which increases towards the end of the cone, and at the point is most intense. A common flame thus becomes a small furnace: so that a small piece of any substance may be subjected to a high temperature almost instantly, and fused. It is much used in soldering by the jeweller, goldsmith, and workers in fine metal; by the glass-blower and the enameller. In the hands of the analytic chemist it is an invaluable instrument. The mouth blow-pipe is a small tube tapering gradually to a fine point, having a small bulb intermediate, not far from the fine jet. The latter blow-pipe is blown with a bellows instead of the mouth.

BLUBBER. The cellular membrane in which the oil or fat of the whale is included. Its thickness varies from eight to twenty inches, and yields as much frequently as 100 tons of oil from a full-grown whale. It is generally brought home from the fishing-ground packed in casks. The oil is drained out of the blubber by placing the latter cut up on racks, through which the oil drips down into casks. It is then heated up to 225°, to deprive it of its rancid smell, and also to make the grosser parts settle. The oil is then pumped over with cool water, left to cool, and finally stored in casks.

BOATS—LIFE-BOATS. Since the extensive application of India-rubber and gutta percha to useful purposes, these substances have been employed with much success in the constitution of life-boats and buoys. (*See* LIFE BOAT.)

BOMBAZINE. A fabric, the warp of which is silk and the weft worsted. It It is chiefly made in black, and is an article of mourning for female dress.

BOLE. An earthy mineral; a hydrated silicate of alumina, resembling soapstone. When put in water it absorbs it, and falls to pieces. Armenian bole is used as an ingredient of tooth-powders, and it also enters into the composition of common red paints.

BONE. An important organ in the higher orders of animals, forming the solid support of their fabric, and protecting the vital organs, such as the brain and the heart and lungs, from external pressure and injury. In the human skeleton there are commonly enumerated 260 distinct bones. They, however, admit of classification under three heads: namely, *long* or *cylindrical* bones, such as those of the extremities; *broad* and *flat* bones, such as those of the skull; and *short*, *square*, *irregular*, or *solid* bones, such as the vertebræ, and those of the wrist and instep, and the patella or knee-pan: the first bones are generally filled with marrow, and are admirable specimens of strength of structure with the least possible weight. The bones are covered by a membrane called *periosteum*, by which the ramifications of blood-vessels and nerves pass into the bone. In the growth of a bone, the gelatinous or cartilaginous portion, as it has been sometimes called, is first formed, and the earthy or indurating part is afterwards deposited. We are indebted to Mr. Hatchett for our principal information respecting the proximate chemical components of bone. The soft parts consist of gelatine and albumen, and the hard portion is composed of phosphate of lime and carbonate of lime, with small quantities of other salts. The animal matter of bones amounts on an average to about half their weight, or when dried, to between 30 and 40 *per cent.*; so that they contain a large relative proportion of nutritive matter. The bones, including their animal matter, are the most durable parts of the animal fabric: hence the proposal of storing them up as occasional sources of nutriment; for not only is the cartilaginous portion unimpaired, in bones which have been kept dry for many years, but it has even been found perfect in bones of apparently antediluvian origin. The best mode of extracting the nutritious part of bone for human food consists in grinding it fine, and subjecting it with water to a heat of about 220° in a digester; or the earthy part may be removed by dilute muriatic acid. When dogs and some other animals devour bones, the nutritive part is abstracted by their gastric juice, and the earthy part is voided in their excrement, forming what was formerly called *album græcum*.

When bones are submitted to destructive distillation, the gelatine and albumen which they contain is abundantly productive of *ammonia*; hence a copious source of that alkali and its compounds; the residue is a mixture of the earthy part of the bone with charcoal, commonly termed *ivory* or *bone black*.

BONE DUST, or ground bones, has recently been used with the best effect as a *manure*. It is usually applied to light or turnip soils, which it has rendered in no ordinary degree productive. It is an excellent addition to grass land, and its application generally is too much neglected in this country, where a large exportation of bones to England occurs yearly from Boston. The agriculture of the Atlantic States requires the use of bones as much as that of England does.

BONE EARTH. The residue of bones which have been calcined so as to destroy the animal matter and carbon, and become converted into a white porous and friable substance, composed chiefly of phosphate of lime. According to Berzelius, 100 parts of human bones are composed of 51·04 phosphate of lime, 11·30 carbonate of lime, 2 fluoride of calcium, 1·20 soda and chloride of sodium, 1·16 phosphate of magnesia, and 33·30 animal matter. Albumen, gelatine, and fat constitute the animal part of bone, the greater part of which remains in the form of a tough cartilage when bones are steeped in dilute muriatic acid.

In the arts, bones are employed by cutlers, turners, manufacturers of animal charcoal, and by assayers for making cupels.

BONE BLACK is the carbonaceous substance which remains after the calcination of bones in close vessels. This kind of charcoal has two applications: to deprive syrups and other solutions of their coloring matters, and to furnish a black pigment. (*See* Ivory Black.) In the calcination bones lose half their weight, and the resulting charcoal is more valuable when the bones have been steamed previously, so as to remove fat and membrane. It is after being calcined, ground in a mill, and sifted. In the calcination volatile inflammable gases and oils are given off,—the latter are used to form *lamp black*; at the close of the process muriate of ammonia and sulphate of soda,—the latter is washed out, and the former, which is a valuable salt, is sublimed.

Bone black has a remarkable attraction for organic coloring matter; this varies with the heat at which it was made: if too high, it becomes glazed; if too low a heat was employed, the albumen of the bone is not destroyed. After this charcoal has been used, it may be renovated by heating it to redness in a furnace.

BOOKBINDING. There are several and distinct branches of this business,—plain and ornamental binding,—law binding,—blank book and ledger binding; the latter is a department in itself, and usually conducted by stationers.

The various sizes of a book are designated by the number of leaves in which the sheet is folded: thus folio is 2 leaves; quarto, 4 leaves; octavo, 8 leaves; duodecimo, 12 to a sheet; and so on to the smallest sizes of 24mo and 32mo. After the sheets of a book have been folded, they are collated by the *numeral* or letter placed at the foot of the first page in the first sheet, in order to ascertain that the work is perfect. The next process is that of pressing: this is done in a hydraulic press. The back of the sheets is then sawed by machine, after which the sewing process commences. This last is a quick operation, as a girl can sew three thousand sheets a day. The middle of the sheets are stitched with thread to the upright cords fastened on the press; as soon as one sheet is fastened to all the strings, another is laid down on it, and fastened in a similar manner. India-rubber binding supersedes the necessity of sewing, binding every leaf as securely, and giving greater flexibility.

When the sewing is finished the strings are cut, leaving an inch or so hanging, which are used to fasten the book to its case. The backs of the sheets are now all glued to increase the connection.

By hammering on wooden blocks, or better still, by passing the sheets between rollers, the back is rounded and the front hollowed out, and a grooved hollow made, into which the millboard is fitted, the covers being fastened by the strings through the boards. The book is next placed between boards and screwed up in a press, with one of its ends projecting. The ends of the leaves are now cut off fair by a plough, the cutting edge of which, in its action, is midway between a knife and a plane-iron. When books are bound in leather, the sides of the covers are previously stamped with a device, or embossed as it is termed. The embossing machine sometimes exerts a pressure of 50 tons. The devices on the back, edges, and margin, are placed on by hand with a revolving wheel, which has on its edge the device cut out, and which leaves its impression when the wheel is rolled along.

Gutta percha has lately been introduced into binding, to imitate the antique old oak binding.

When books are to be gilt, the edges are scraped and burnished with the agate burnisher, then colored over with red bole or chalk, ground in soap, rubbed in fine paper, and again well burnished; this brightens up the gilding. The gold leaf is then cut into slips, and laid on. Gilding on marbled edges has a very beautiful effect, as the marbling is perceived through the gold.

Several of the book binderies in New-York, Philadelphia, and Boston, employ from fifty to one hundred persons, including females who stitch and fold.

BORACIC ACID. (*See* Boron.)

BORAX. This salt is found native in some of the lakes of Thibet and Persia, and is imported from India under the name of *tincal*, which, after purification, forms the *refined borax* of commerce. Of late years borax has been obtained by combining *native boracic acid* with soda. Borax forms hexahedral prisms, slightly efflorescent, and requiring 20 of cold and 6 of boiling water for solution. When heated, water of crystallization is driven off, and the residuary salt fuses into what is called *glass of borax*.

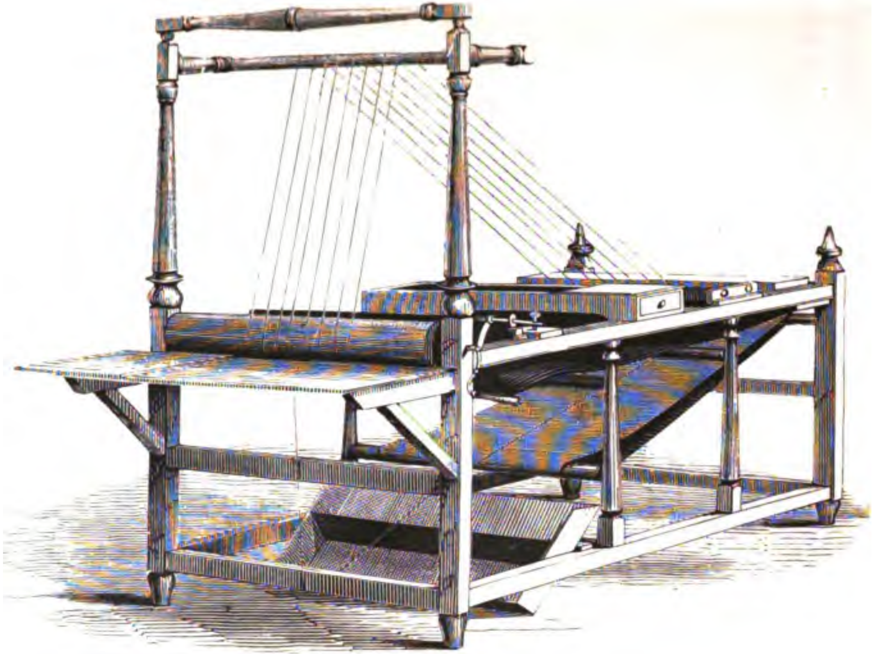
Crystallized borax consists of 68 boracic acid + 32 soda + 90 water. It has upon some tests an alkaline reaction, and has hence been called *sub-borate of soda*. Borax is chiefly used by workers in metals as a flux: it is also employed in medicine.

Dry borax acts on metallic oxides at a high temperature, melting and vitrifying them into beautiful colored glasses, on which account it is a most useful reagent with the blow-pipe. It tinges oxide of chrome, emerald green; oxide of cobalt, intense blue; oxide of copper, pale green; oxide of tin, opal; oxide of iron, bottle-green; oxide manganese, violet. In the fusion of metals it protects the surface from oxidizement, and dissolves any oxides off the surface: hence it is an excellent flux in the hands of the goldsmith, in soldering precious metals, and to the brazier, in soldering copper and iron. When mixed with shell-lac, in the ratio of 1 to 5, it renders the lac soluble in water, and forms with it a species of varnish.

BORON. The base of boracic acid, discovered by Davy in 1807. It may be procured by heating dry boracic acid with potassium. It is a dark olive-colored substance, a nonconductor of electricity, insoluble in water, infusable, and of a specific gravity = 2, Heated to redness it burns into *boracic acid*, which consists of 20 boron + 48 oxygen.

Boracic acid is found in the hot springs, and amongst the volcanic products of the Lipari islands, and in the waters of Sasso in the Florentine territory; it also occurs in some minerals. It may be obtained by adding excess of sulphuric acid to a strong solution of borax. Its specific gravity is 1·48. In its usual state of scaly crystals it is a *hydrate*, composed of 68 dry acid + 27 water. In this state it requires about 30 parts of cold and 3 of boiling water for its solution. It dissolves in alcohol, and the solution burns with a characteristic green flame. It reddens litmus; but renders turmeric brown, like an alkali. When its water is driven off by fusing it at a high heat, the anhydrous acid concretes into a glassy substance of the specific gravity of 1·8. It is a useful flux, and was formerly used in medicine under the name of *Homberg's sedative salt.*

The boracic acid lagoons of Tuscany are an interesting instance of the conversion of a natural phenomenon, which seemed only a subject of wonder, into a productive manufacture. These lagoons are depressions or mud holes in the soil, from which issue hot vapors highly impregnated with boracic acid, which were formerly regarded with terror by the inhabitants of their vicinity, and they sought by public prayers a deliverance from this scourge. In 1818, Mr. Landerel conceived the idea of rendering these vapors a source of profit. The lagoons being situated upon the declivity of a mountain, they were surrounded by a basin of mason work, and water from the mountain stream conducted into them, so as to form a series of artificial lakes at different levels. The water is let into the upper basin, where it remains some twenty or thirty hours and becomes impregnated by the acid vapors; at the end of this time the water is drawn off into the second basin, when it receives a further pregnation; and so on successively through six or eight, until it reaches the evaporating reservoirs. These are



RULING MACHINE, FOR BLANK BOOKS, BILLS, LETTERS, &c. Page 46

of lead, and the heat for carrying on the evaporation is obtained from the vapors themselves, which are brought in pipes below the boilers. All the means of manufacture are furnished by the locality itself. The annual product of these lagoons is two and a half millions of pounds. The boracic acid is converted into borax by combining with soda.

BOTTLE. (*See* GLASS).

BRAN. The husk of wheat which immediately covers the grain, and which remains in the bolting machine. It is gently laxative; an infusion of it, under the name of *bran tea*, is frequently used as a domestic remedy for coughs and hoarseness. *Calico printers* employ bran and warm water with great success to remove coloring matter from those parts of their goods which are not mordanted. This appears to be due to the quantity of earthy phosphates which the bran contains.

BRANDY. A spirituous product obtained by distilling wine: the quality varies with the wine employed. When pure it is perfectly colorless, and only acquires a pale-brown or yellow tint from the cask. The deep color of common brandy, intended to imitate that which it acquires from great age in the cask, is generally given by the addition of burned sugar. The average proportion of alcohol in brandy varies from 48 to 54 per cent. The best brandy is made in France, the preference being generally given to that shipped from Cognac. (*See* DISTILLATION).

BRASS. An alloy of copper and zinc: to make brass, the English method is by melting together copper in round masses, or in bars, with calamine, which is a native oxyde or ore of zinc, and a native carburet of zinc combined with oxyde of iron, which make it of reddish color, and it usually contains more or less lead. The calamine is powdered and separated by washing, then heated on the hearth of a reverberatory furnace, which expels the volatile matter, usually water and carbonic acid. The remainder is oxyde of zinc, and a small portion of carbon, which the heat cannot wholly remove, and some earthy substances. The proportions are nearly equal weights of copper and calamine and one-tenth of their weight of pulverized charcoal, which are together put into a crucible capable of containing 100 pounds of brass when completed, but when charged holding 663, calamine 83, and charcoal 18, which is covered with clay, sand, &c., to keep it free from the air. The fire is continued from twelve to twenty hours, when the refuse is poured off, the metal cast into ingots, then usually remelted and cast, to render it better and finer, when it is rolled, drawn, or made into castings for use.

Brass is often made by melting together small pieces of cast copper and zinc, which is made into ingots, then rolled into sheets slitted and drawn into wire. For knife scales, sheet brass is used which is not annealed, but stiff and hard. Corinthian brass, famous in antiquity, was an alloy of gold, silver, and copper. Lucius Numminus, 146 years before Christ, captured and burned the city of Corinth; and the violence of the conflagration formed, from the abundance of metals in its course, a solid sea of this alloy in the streets and low places. German chemists make copper of a gold color, by exposing it to the fumes of zinc. The comparative stiffness of this alloy permits it to be cut by saws and files, turned and worked much easier than iron. The metal anciently called brass, is the copper of modern times; and the Colossus at Rhodes, and other so-called brazen fabrics, were formed entirely of the last named metal.

Brass-making was introduced into England in 1694, where it proved a failure to its first manufacturers, but it is now a great business in that country. Brass must be annealed after it is cast into moulds, or it will be so brittle that it cannot be drawn. Brass is lighter than pure copper, but it is harder. It is only malleable while cold. If brass is heated beyond a cherry red, the zinc separates from the copper in the form of gas. There are a great variety of brass alloys. Four parts of copper and two of zinc, makes a beautiful brass. The copper must be first melted then the zinc is introduced, and as soon as it is melted it must be stirred then run into the mould. The reason for doing this is, that zinc is volatilized at the heat of fluid copper, therefore, if the zinc and copper were introduced together, before the copper was all melted a great portion of the zinc would have departed in the state of vapor.

The usual proportion of metals in yellow brass, is 30 of zinc and 70 of copper.

Tomback or red brass, is an alloy of copper and zinc containing not more than 20 per cent. of the latter.

Pinchbeck, is made of 2 parts copper and 1 of yellow brass.

Prince's Metal, 3 parts copper and 1 of zinc.

Mannheim gold, 28 copper, 12 yellow brass, and 8 tin.

Cast white metal-buttons, are made of an alloy of 32 parts brass (yellow), 4 parts of zinc, and 2 of tin.

The French state that brass containing two per cent. of lead works more freely in the turning-lathe, but does not hammer so well as the ordinary brass.

BRASS FOIL. Dutch-leaf: it is made from very thin sheet brass, beat out under a hammer worked by water power which gives 3 or 400 strokes per minute: from 40 to 80 leaves being laid over each other. By this treatment it acquires its characteristic solidity and lustre.

BRAZIL WOOD. A valuable wood, imported from South America and the West Indies, where it is produced by certain species of *Cæsalpinia*, especially *C. echinata* and *Braziliensis;* large trees with repeatedly pinnated leaves, showy yellow flowers, and long richly colored stamens. It is used for the preparation of a red dye, but the consumption of it in this country is inconsiderable. The coloring matter is easily affected by acids, producing an orange or yellow color which is durable: with alkalies, a violet and purple color is produced—these are fleeting. The color given to silks, known as false crimson, is by means of Brazil wood. The silk is boiled with 20 parts of soap, rinsed and passed through a bath charged with this wood. Stronger colors are gained by giving a ground of annotto to the silk, or by adding logwood to the bath.

Nicaragua and peach wood, are varieties of the Cæsalpinia, and produce dyes.

The coloring substances belonging to Brazil, are called by chemists *braziline* and *brazileine;* the first being the coloring matter of the wood, and the second a colorless substance which appears to pass into the proper coloring matter by oxidation.

BREAD. (Ger. brod.) This important article of food is made of the flour of different grains; but it is only those which contain gluten that admit of conversion into a light or porous and spongy bread, of which *wheaten bread* furnishes the best example. When flour is made into a tough paste or *dough* by the addition of a little water, rolled out into thin cakes, and more or less baked, it forms *biscuit*. For the formation of *bread* a certain degree of fermentation, not unlike vinous fermentation, is requisite, care being taken to avoid acetous fermentation, which renders the bread sour, and to most persons disagreeable. If dough be left to itself in a moderately warm place (between 80° and 120°), a degree of fermentation comes on, which, however, is sluggish, or, if rapid, *acetous;* so that to effect that kind of fermentation requisite for the production of the best bread, a *ferment* is added, which is either *leaven* or dough which is already in a fermenting state, and which tends to accelerate the process in the mass to which it is added; or *yeast*, the peculiar matter which collects in the form of scum upon beer in the act of fermentation. Of these ferments leaven is slow and uncertain in its effect, and gives a sour and often slightly putrid flavor. Yeast is more effective; and when clean and good, it rapidly induces *panary fermentation;* but it is often bitter, and sometimes has a peculiarly disagreeable smell and taste.

All, then, that is essential to make a loaf of bread is dough to which a certain quantity of yeast has been added. This mixture is put into any convenient mould or form, or merely shaped into one mass; and after having been kept for a short time in rather a warm place, so that fermentation may have begun, it is subjected to the process of baking in a proper oven. Carbonic acid is generated; and the viscidity or texture of the dough preventing the immediate escape of that gas, the whole mass is puffed up by it, and a light porous bread is the result. Along with the carbonic acid traces of alcohol are at the same time produced, but so insignificant and impure as not to be worth notice; hence the attempts which have been made to collect it upon the large scale have entirely failed in an economical point of view. Other flour besides that of wheat will, under similar circumstances, undergo panary fermentation: but the result is a heavy, unpalatable, and often indigestible bread; so that the addition of a certain quantity of wheat flour is almost always had recourse to. It is the *gluten* in wheat which thus peculiarly fits it for the manufacture of bread, chiefly in consequence of the tough and elastic viscidity which it confers upon the dough.

It is well known that *home-made bread* and *baker's bread* are two very different things: the former is usually sweeter, lighter, and more retentive of moisture; the latter, if eaten soon after it has cooled, is pleasant and spongy; but if kept for more than two or three days, it becomes harsh and unpalatable. The cause of this difference may perhaps be obvious from the following details of the operations of the wholesale baker.

In making his dough he takes the water, or part of it, which he intends to use, and having slightly warmed it, dissolves in it a certain portion of salt; then he adds the yeast, and then a certain quantity of flour. This mixture is set aside in a warm place, where it soon begins to ferment. This process is called *setting the sponge;* and according to the relation which the water in it bears to the whole quantity to be used in the dough, it is called whole, half, or quartern sponge. The evolution of carbonic acid causes the sponge to heave and swell; and when the surface bursts it subsides, and then swells again, and so on; but the baker is careful to use it before this fermentation has communicated sourness to the mass. He then adds to the sponge the remaining quantity of flour, water, and salt, which may be required to form dough of proper quality and consistence, and incorporates the whole by long and laborious kneadings till the entire mass acquires uniformity, and is so tough and elastic as to bear the pressure of the hand without adhering to it. It is then left for a few hours, during which fermentation goes on; and the inflated mass is again kneaded, so as to break down any lumps or portions which had accidentally escaped diffusion in the first operation, and to confer perfect uniformity on the whole. The dough is then weighed out into loaves, which are shaped, and put aside in a warm place for an hour or two, during which they swell up to about double their original size; they are then put into the oven and baked: during which operation they again enlarge considerably in bulk, in consequence of the dilatation of the previously generated carbonic acid pent up in the dough; for, as soon as the mass is exposed to the heat of the oven, the fermentation is put an end to.

If we compare the baked loaf with the flour of which it is composed, we shall find that panary fermentation has produced a considerable change in the latter. The gluten and the starch, which (exclusive of a trace of sugar) were the components of the flour, have mutually acted upon and altered each other; the toughness and viscidity of the gluten is gone, and the starch no longer forms a gelatinous mixture with hot water; a little sugar is generally formed, as well as alcohol; but the principal cause of the change in the characters of the flour is the evolution of carbon and of oxygen in the form of carbonic acid, the production of which is independent of the presence of external oxygen (or of air). Small quantities of alum are also, it is said, invariably used with the view of whitening or bleaching the bread; for it may be observed, that whatever may be the quality of flour which is used, home-made bread is always of a comparatively dingy hue. According to Mr. Accum, the requisite quantity of alum for this purpose depends upon the quality of the flour. The mealman, he says, makes different sorts of flour from the same kind of grain. The best flour is chiefly used for biscuits and pastry, and the inferior kinds for bread. The smallest quantity of alum used is from three to four ounces to the sack of flour of 240 pounds.

Another article occasionally employed in bread-making is carbonate of ammonia. As it is wholly dissipated by the heat of the oven, none remains in the baked loaf. It renders the bread light, and perhaps neutralizes any acid that may have been formed (exclusive of carbonic acid); but it is too dear to be much employed. To some kinds of biscuit it gives a peculiar shortness, and a few of the most celebrated manufacturers use it largely. The French chemists have accused the bakers of employing sulphate of copper or blue vitriol, for the purpose of improving the color of the bread; but so dangerous and easily detected an addition can scarcely be supposed to be common. According to Mr. E. Davy, bread, especially that of indifferent flour, is materially improved by the addition of a little carbonate of magnesia, in the proportion of twenty to thirty grains to the pound of flour; it requires to be very intimately mixed with the dough. The most nefarious adulteration of bread consists, however, in the addition of certain insipid and colorless earthy substances, with a view of increasing its weight; such as pipe-clay, porcelain clay, chalk, and plaster of Paris. These, however, are probably very rarely resorted to; though in one instance the writer of this article had occasion to examine a quantity of *biscuits*, which were adulterated with gypsum to the amount of 10 *per cent.*

For the manufacture of domestic bread the following, perhaps, may not be unacceptable.

White Bread.—Take an earthen vessel, larger at the top than the bottom, and in it put a pint of milk-warm water, 1½ lbs. of flour and ½ pint of good malt yeast; mix these well together and set it away (in winter it should be in a warm place) until it rises and falls again, which will be in from three to five hours. It may be set at night if wanted in the morning. Then put two large table-spoons full of salt into two quarts of water, and mix it well with the above rising. Then put in nine pounds of flour, and work your dough well: then set it by until it becomes light. Then make it out in loaves, of which it will make four. As some flour is "dry," and other "runny," the above quantity will be a guide. The person making bread will observe that runny, or new flour, will require one-fourth more salt than old or dry flour. The water also should be tempered according to the weather. In spring and fall it should only be milk-warm. In hot weather cold, and in winter warm.

Brown Bread.—Take one part of rye meal and two parts of Indian meal, mix it well, add a little salt, and thoroughly wet the whole with boiling milk. Stir it frequently, until cold, and add cold milk till it is thin enough to pour into pans. Bake it in a brick oven five or six hours.

Take six quarts of water, one teacup full of salt, one pint of lard or other clean grease, one pint of yeast, the whole to be quite warm; then stir in meal enough to make a stiff batter, let it stand till it rises, then mix up and put in pans to bake. The quanties can of course be reduced proportionately as desired.

Unfermented Bread.—Five pounds of flour, ½ oz. sesqui carbonate soda, ½ dram sesqui carbonate of ammonia, 4 teaspoonfuls of common salt. Mix well together, and then add 2½ pints (50 oz.) cold water, and 5 drams of hydroclorie acid. It requires 1½ hours to bake.

The theory of *panification* (bread-baking) is easy of comprehension. The flour owes this valuable quality to the gluten, which it contains in greater abundance than any other of the *cerealia* (kinds of corn). This substance does not constitute, as had heretofore been imagined, the membranes of the tissue of the perisperm of the wheat; but is inclosed in cells of that tissue under the epidermic coats, even to the centre of the grain. In this respect the gluten lies in a situation analogous to that of the starch, and of most of the immediate principles of vegetables. The other immediate principles which play a part in *panification* are particularly the starch and the sugar; and they all operate as follows:—

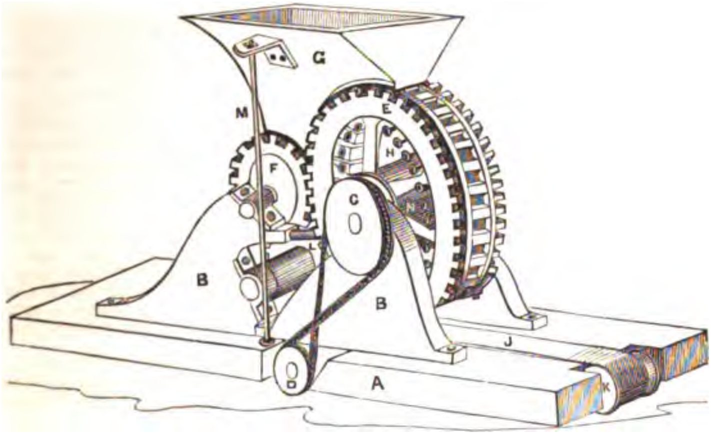
The diffusion of the flour through the water, *hydrates* the starch and dissolves the sugar, the albumen, and some other soluble matters. The kneading of the dough, by completing these reactions through a more intimate union, favors also the fermentation of the sugar, by bringing its particles into close contact with those of the leaven or yeast; and the drawing out and malaxating the dough softens and stratifies it, introducing at the same time oxygen to aid the fermentation. The dough, when distributed and formed into loaves, is kept some time in a gentle warmth, in the folds of the cloth, pans, &c., a circumstance propitious to the development of their volume by fermentation. The dimensions of all the lumps of dough now gradually enlarge, from the disengagement of carbonic acid in the decomposition of the sugar; which gas is imprisoned by the glutinous paste. Were these phenomena to continue too long, the dough would become too vesicular; they must, therefore, be stopped at the proper point of sponginess, by placing the loaf lumps in the oven. Though this causes a sudden expansion of the enclosed gaseous globules, it puts an end to the fermentation, and to their growth, as also evaporates a portion of their water.

The richness or nutritive powers of sound flour and also of bread are proportional to the quantity of gluten they contain. It is of great importance to determine this point, for both of these objects are of enormous value and consumption; and it may be accomplished most easily and exactly by digesting in a water-bath, at a temperature of 167° F., 1000 grains of bread (or flour) with 1000 grains of bruised barley-malt, in 5,000 grains or in a little more than half a pint, of water. When this mixture ceases to take a blue color from iodine (that is, when all the starch is converted into soluble dextrine) the gluten left unchanged may be collected on a filter cloth, washed, dried at a heat of 212°, and weighed. The color, texture, and taste of the gluten, ought also to be examined, in forming a judgment of good flour, or bread. (See Flour.)

BRICK. (Dutch, bricke.) In architecture, a mass of clay earth, sometimes mixed with coal ashes, chalk, and other substances, formed in a mould, and burned in a kiln or clamp. The earth used for this purpose is of two sorts.

The one a stiff clay, with little or no extraneous mixture, which produces a hard red brick; the other a yellowish-colored fat earth, called loam, which produces a gray-colored brick. The clay is usually tempered in a clay mill. For the sea coal ashes that are mixed with it in cities, they substitute in the country a light sandy earth. In making the paste as little water should be introduced as possible. In moulding them, which is done in a wooden mould, a clever workman will mould about five thousand in fifteen hours. The kiln in which they are burnt is a large building, about 13 feet long, 10 feet 6 inches wide, and 12 feet high, furnished with a proper furnace. When otherwise burnt, the *clamp*, as it is called, is formed of the bricks themselves, generally oblong on the plan, and the foundations made with place bricks. Each course of bricks is laid on a layer of *breeze* or cinders; and flues are formed, filled with coals, breeze, and wood. The burning continues from twenty to thirty days. The size of bricks, when burnt, is required in England to be 8½ inches long, 2½ inches thick, and 4 inches wide. The different varieties of bricks are, *malms*, which are of a yellowish uniform color and texture; *seconds*, not quite so uniform in color and texture as malms; *red* and *grey stocks*, the former being burnt in kilns, both of a quality rather inferior to seconds; *place bricks* or *peckings*, sometimes called sandel or samel bricks, which are those furthest from the fire, and rarely well burnt,—these should never be used in a building where durability is required; *burrs* or *clinkers*, which are masses of several bricks run together in the clamp or kiln from the violent action of the fire; *fire bricks*, of a red color, about 9 inches long, 4½ inches broad, and an inch and a half thick,—they are made for use in furnaces to resist the action of the fire, and from having been formerly manufactured in the neighborhood of Windsor, they are sometimes called Windsor bricks; *paving bricks*, made for the purpose their name implies; *compass bricks*, are circular on the plan, chiefly used in walling wells and the like; *Dutch clinkers* or *Flemish bricks*, chiefly used in stables; the Dutch clinkers 6 inches long, 3 inches broad, and 1 inch thick.

The moulding of bricks in this country is altogether performed by machinery; one of the latest improvements in which is the invention of J. Z. A. Wagner, of Philadelphia, of which the annexed is an illustration.



This machine consists of a large revolving metal wheel, which has a number of boxes in its periphery, of the form of the brick to be moulded, and which constitute the moulds. In the inside of these moulds are plungers, which recede to allow the clay to come in for moulding, but when they come to an endless apron below, a cam acts upon the said plungers, and they push out the bricks, delivering them on the endless apron to be carried away. This is an outline of its main working features. A is the metal base of the machine; B is the frame; C is a pully on the shaft of the mould wheel, E. The rims of the mould wheel are made of toothed gearing, and gear into wheels, F (one on each side), of a pressure metal roller, which works close up against the face of the mould wheel, excepting that part opposite the moulds, which is a little recessed all around, leaving a space between the two; D is a pulley to drive the drum O (fig. 2), of the endless apron, J. G is the hopper to receive the prepared clay. This hopper is supported by screw rods or posts, M (one on each side). The hopper has a rim which fits snugly into recesses in the mould wheel, and the pressure roller, F, to keep the clay from getting between the teeth of the wheels. In case, however, that the moulded brick might stick to the end of the plunger, Mr. Wagner has attached a lever on each side, secured to the inside of the frame, B, under the mould wheel and above the apron, and the end of these levers are touched by cams on each side of the mould wheel (one cam for each mould) when the lever immediately pushes the moulded brick from contact with the mould wheel, and it drops on the carrying apron. The first roller, F, acts like a feed roller to pack the moulds with the clay, but leaving a little clay projecting out, and then the second pressure roller, by being placed closer to the face of the moulds, presses the clay solidly into the moulds, and smooths the face of the brick. This is a rotary brick moulding machine.

Mr. H. Roberts, of Hyde Park, London, has lately taken out a patent for a new kind of bricks, which are so made that there will be no vertical joints in the wall which may be built of them, as are now made by the headers, where the English and Flemish *bonds* are used. The bricks are made hollow to be lighter. They are made so that one side of the brick is inclined to the top or the bottom, or the one part projecting beyond the other, so that one brick being laid the other is to be reversed, so that the projecting sides of the bricks will fit into one another, to bond the work, using only stretchers to avoid vertical joints.

Mr. Legros has taken out a patent in London for machines to mould bricks, tiles, and other articles, by which superior produce is obtained at less cost. In one of his inventions Mr. L. has adapted the principle of motion on a small railway to the performance of the several steps of the manufacture. For this purpose rails are laid down so as to traverse on the same level all the buildings in which the various parts of the machinery are erected. One machine will turn out 66 bricks in a minute, or 40,000 in a day, at an economy of one dollar per thousand.

BRIDGE. (Sax. brigge.) In Architecture, a structure for the purpose of connecting the opposite banks of a river, gorge, valley, &c. &c., by means of certain materials, forming a roadway from one side to the other. It may be of stone, brick, iron, timber, suspended chains or ropes; or the roadway may be formed by means of boats. Long previous to the introduction of bridges constructed upon geometrical principles, the modes of crossing rivers by throwing the trunks of trees across them, or by suspension of ropes, or twisting together the branches of trees from bank to bank, were so obvious that they must have been resorted to at an early period. The former method, however, could only have been practised over narrow streams, whilst the latter might have been carried to almost any required extent. Mungo Park found this mode employed in Africa: and in South America rope bridges of bujuco, or thongs made from the hides of oxen, are in use at the present day. Don Antonio de Ulloa tells us, that over some of the rivers of Peru the bujuco bridges are of such dimensions that loaded mules in droves pass over them, and especially on the river Apurimac, forming the high road for the trade carried on between Lima, Cuzco, and other places to the southward. Though such bridges are the contrivance of man in a less civilized state, they are the only means by which many streams whose currents are deep and rapid can be crossed; and the stupendous suspension bridges of the present day are but improvements on the simple scheme of the untutored architect of a savage period and people.

The use of the arch in bridging appears to have been first practically applied by the Romans. The Chinese, though using the arch, did not make it strong enough to bear wheel carriages. In Egypt and India it was unknown, or was not applied. There is no trace of the arch in the ancient works of Phenicia and Persia, and even the Greeks have a doubtful claim to it. Over the Tiber the ancient Romans built wooden bridges; such was that which joined the Janiculum to the Mons Aventinus, and was called the Pons Sublicius, from the word *sublicæ* (stakes) of which it was formed. Without enumerating the bridges of Rome, some of which are still standing to attest the science of their architects, we must mention the Pons Narniensis, on the Flaminian way, near Narni, and about sixty miles from Rome. It was built by Augustus, and vestiges of it remain to the present day, one arch above 150 feet span and 100 feet high being still entire. But of works of art, perhaps the most wonderful ever raised was the bridge built by Trajan over the Danube. It consisted of twenty piers, whose height from their foundation was 150 feet, and 170 feet apart; its breadth being sixty feet. This stupendous work was demolished by Hadrian, the successor of Trajan, under the pretence that it might serve as a passage for the barbarians, if they became masters of it; but some writers have said it was through envy of the fame that attached to its founder. Over the Tagus, in Spain, an ancient Roman bridge, near Alcantara, is still partly standing. It consisted of six arches of eighty feet span, extending altogether 600 feet in length, and some of the arches 200 feet high above the water. Of the temporary bridges of the Romans, the most famous was that of timber thrown by Cæsar over the Rhine.

From the fall of the Roman Empire to the revival of the arts, the history of bridge architecture is, with the exception of the Moorish works in Spain, of no interest. It appears from Gautier, who uses the authority of Mag. Agricola of Aix, that when the arts began to revive in Europe, an order was founded by St. Benezet, under the title of Brethren of the Bridge; and that under them was begun, in 1176, the bridge at Avignon, consisting of eighteen arches and about 3000 feet in length. During the contentions of the popes, in 1385, some of its arches were destroyed, and in 1602 three others fell. In 1670 the ice destroyed all but the third pier, which, with the Chapel of St. Nicholas upon it, still remains. In 1354 a bridge of three arches was constructed at Verona, the roadway sloping from the city; the largest of its arches, which are segmental, is 160 feet span; but a still larger arch was built at Vielle-Brioude in France, over the Allier, in 1454. of nearly 184 feet span, which is the largest stone arch upon record. Among the most celebrated bridges of Italy, is that of the Rialto at Venice, whose span is 98½ feet. It was begun in 1588, and finished in 1591, from the designs of Antonio dal Ponte, though by most authors absurdly attributed to M. A. Buonarroti. In this city alone there are no less than 889 bridges; but they are mostly of small spans. We must not omit in this place the bridge of Della Santissima Trinità, at Florence, by Ammanati, which, as Milizia truly observes, has not been surpassed since the revival of architecture. It is of three arches, the middle one of 96 and the two side ones 86 feet span, the width of the piers being 26 feet 9 inches; the breadth of the carriage and footways between the parapets is 33 feet. It has been usual for writers to call the form of the arches of this bridge cycloidal; but from our own measurements and most particular investigation, we can assert that they are not of that form. They are very slightly pointed, after the fashion of what is called the Tudor arch of this country; the point at the summit, which is extremely obtuse, being hidden by the ram's head sculptured on the key-stones. During the two last centuries, the French have advanced their bridge architecture to very great perfection; but more particularly in the latter part of the last century, in which appeared Perronet, the father of the modern system of the art, whose elegant designs have not since been improved upon, either in France or in any other country. His is the beautiful bridge of Neuilly over the Seine. It consists of five arches, each about 128 feet span and 32 feet rise: it was finished in 1774, and remains a splendid monument of the powers of its architect. Some of the more modern specimens of their bridges do great honor to the French school, in which beauty of form is united with sound engineering.

In England, the progress of bridge architecture has kept pace with that of the Continent; and if her bridges cannot boast the elegance in design of her lively neighbors, they are fully equal to them in boldness of conception and execution of the work. Indeed, if the designs of the late Messrs. Telford and Rennie had been equal to their engineering skill, no country in the world would have been able to compete with what she would have been able to exhibit. And here must not be forgotten the bridge over the river Taff, near Llantrissart, in Glamorganshire, celebrated for its great span; the work of William Edwards, a country mason, in 1755. The chord line is 140 feet, and the versed sine 35 feet.

Of timber bridges the boldest and most ingeniously constructed was that at Schaffhausen, in Switzerland, destroyed by the French in 1799. It was designed and executed by Grubenman, a common carpenter, in 1758. The total length of the bridge was 364 feet, but it was relieved by a pier in the middle of the river.

This country has some of the grandest specimens of timber bridges in the world. The Colossal bridge over the Schuylkill, at Philadelphia (since burnt) was 340 feet span, with a rise of only 20 feet, and the thickness of the timber at the vertex only 7 feet. That at Piscataqua, over the river of same name, has a span of 250 feet, and a rise of 27, built in 1794 by Palmer.

The bridge of the Kennebec and Portland Railroad, over the Androscoggin River at Topsham, is one of the largest and most substantial structures of the kind in the United States. It is a deck bridge, the upright posts and rods being about 18 feet from the lower to the upper deck. One of them reaching from centre to centre of the piers, is one hundred and eighty feet. The piers are of granite laid in the most durable manner. The whole length of the bridge is over seven hundred feet. The track of the road along the upper deck will be about fifty feet above tide water. The large lower and upright timbers, and the iron work, together with the X work between decks, give the bridge an appearance of strength and solidity sufficient for any weight.

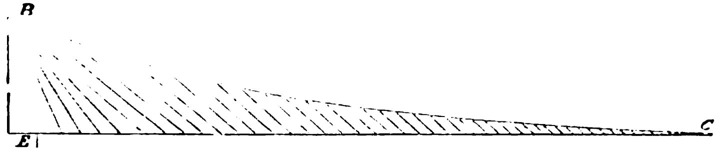
Suspension bridges derive their chief value from the fact of their independence of the bed of the river. Hence they may be used where it is impossible from the force of the current or the altitude of the banks to erect centreing for a stone bridge. They are built with ease and expedition, and are economical. The celebrated suspension bridge over the Menai Strait, by the late Mr. Telford, is almost the giant of its species, and renders unnecessary any enumeration of others. It consists of one opening of 560 feet between the points of suspension, the height between high water and the under side of the roadway being 100 feet. The platform is 30 feet in breadth. The whole is suspended from four lines of strong iron cables by perpendicular rods 5 feet apart. On the tops of the pillars the cables pass over iron rollers, and are fixed under ground to iron frames, which are retained in their places by masonry. The weight of the whole bridge between the points of suspension is 489 tons. In suspension bridges it has been found that the most trying circumstances under which they can be placed, as affecting the stability of their equilibrium, is the heavy and measured tread of a long line of infantry, whose feet drop at the same instant of time.

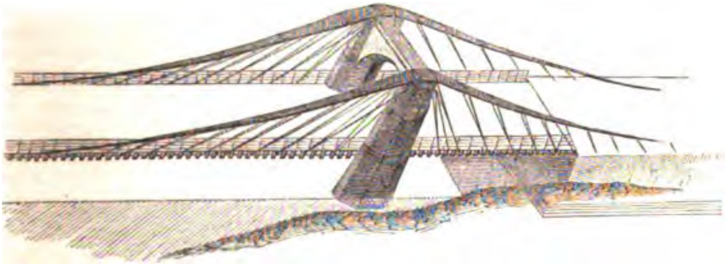
The wire suspension bridge at Wheeling, Va., over the Ohio, has been completed by Charles Ellett, Jr., Architect. The flooring is supported by 12 cables of iron, each cable 4 inches in diameter, composed of 550 strands of No. 10 wire, and is 1,380 feet long; and from centre to centre of the abutments, the flooring is 1,010 feet long, 24 feet wide, with two foot-ways, each 3½ feet, and an intermediate carriage-way 17 feet wide. The cables rest on iron rollers, placed on the summits of the towers, the movements of which will relieve the towers of the strain, and are anchored into the heavy masonry of the wing walls at each end of the bridge. The length of the woodwork which rests on the cables is 960 feet; its weight 546 lbs. per lineal foot, or 524,160 pounds of 262 tons in the whole. The weight of each lineal foot of the 12 cables, composed of 6,600 strands, is 330 pounds, making, with the weight of timber, bolts, castings, suspenders, &c., 920 lbs. per lineal foot, or 441 tons as the permanent weight of the bridge itself. Above its own weight the bridge is constructed to support the greatest transitory weight that is ever likely to be, or we may say, can possibly be brought upon it, such as two columns of teams, and the sides loaded with men, so as to weigh, jointly, 297 tons, or the average weight of 4,000 men, and the strength of the bridge is calculated to support three times the amount of tension that ever can be brought to bear upon it. This bridge will no doubt last long as a monument of American skill and enterprise.

The wire suspension bridge erected across the Cumberland River at Nashville has the following measurements. The length of the bridge is 656 feet, and the whole length of the bridge and embankment 1,956 feet. Width of superstructure, 28 feet; carriage way, 20; two footways, each 4 feet. The bridge will span the Cumberland opposite the southeast corner of the public square of the city, at an elevation of 110 feet above low water, over the main steamboat channel. Base of pier, 60 by 20 feet, solid mason work; anchorage, 60 by 56 on the north side; solid limestone cliff on the south side. There are to be 16 cables, each cable composed of 200 strands of No. 10 wire, each wire tested to bear 1500 lbs. The whole work is calculated to bear a weight of 4,800,000 lbs., or 2400 tons. The cost of this magnificent structure is estimated at but $100,000, though the Wheeling Bridge, 1010 feet long, cost $225,000.

The wire suspension bridge over the Niagara River is the largest of its kind in the world. It is built over the river 1½ miles below the Falls, and directly over the rapids, which commence at this point. It is nearly 800 feet long, and 260 feet above the river. Towers 80 feet high are erected on the bank each side, and at a point 100 feet in their rear the immense wire cables which sustain the bridge are firmly secured. These strands pass from their fastenings immediately over the top of the tower upon either cliff; they pass thence across the chasm, and then over the top of the tower on the opposite cliff, in the rear of which the ends are fastened in the rock. It is 10 feet wide, and a temporary path of wire and slats of wood has been constructed on each side. The flooring is composed of light planks resting upon their scantlings, to which the wires are fastened. Mr. Ellett is the architect.

Mr. Dredge, of Bath, England, builds his suspension bridge on a very improved plan, in which bars connected the roadway to the catenary chain, are not vertical, as in other suspension bridges, but are made by him to pass obliquely from the tower toward the centre, as shown in the cut, where C represents the centre, B the tower, and E the platform; *g* shows the point to which dependence on the tower extends: this tends to strengthen the bridge considerably. The chains in his bridge are made of great thickness at the points of suspension, and taper off to the middle of the bridge, where the strain is least. Mr. Dredge has erected in England, Ireland, and Scotland, many bridges on this plan, which are models of cheapness, beauty, and durability.





This represents a portion of the bridge at Ballock Ferry, Loch Lomond, Scotland, erected on that principle.

Mr. Remington has planned a bridge which appears to be the simplest as yet designed, and is remarkably cheap in construction, according to the length of span. Models of his bridge have been exhibited in New-York and the other cities of the Union, as well as in London. That exhibited in New-York was 160 feet in the clear, composed of four stringers of a little over two inches square at the abutments, and tapering to about an inch square at the centre. It is of the form of an inverted arch. The stringers are made of several pieces of white pine joined together by a scarfe joint; their ends, when they are joined, being bevelled at a very slight angle, and the bevelled parts lapped over each other, and attached with glue, so that when united, each stringer appears to be a continuous and single piece. These jointings are so arranged as that only one of them ever occurs in the same cross section of the bridge, and they are neither bolted nor clamped, but depend entirely upon the glue for their adhesion. Each of these stringers have about nine feet bearing on the abutments or suspension piers, to which they are firmly attached by iron bolts.

At New Orleans, Mr. R. exhibited a model, extending "across a space of ninety-six feet, and elevated some ten feet from the floor. Its appearance is so fragile, that few men, judging from this alone, would willingly trust themselves upon it, yet plenty walk over it and stand on it. It has four longitudinal supporters, each less than one inch square at the centre, but increasing gradually in size, until at the ends or points fastening, they are 2¼ inches square. The bridge has one catenary and two parabolic curves, by which strength and beauty are both secured. The flooring is attached diagonally, and is made to sustain a portion of the strain. The deflexion of the supporters is 22¼ inches. It is capable of bearing the pressure of 7 tons; while each of the supporters, occupying their place in the bridge, will sustain a weight greater than the absolute strength of the timber and the direct cohesion of its fibres."

Upon this plan, Mr. Remington has erected one in Montgomery, Alabama, that was opened for travel last year. The span is 436 feet, and the track is 10 feet wide. It is without hand-rails, and is described as appearing at a distance like a slight ribbon, or shaving of wood, flung across a ravine—apparently too frail to bear the pressure of a bird, but proved to be capable of bearing almost any amount of weight that can be placed upon it. Hundreds of people crossed it on the day it was opened, who were completely convinced of its strength. Its strength is due to the fact that the fibres of the stringers are not subject to any transverse strain, the only action upon them being exerted in the direction of the length of the fibre. Each end of one of its stringers is firmly bolted down to an abutment, and any weight being laid upon them between the abutments, causes just the same tension of the fibres as in the case of an attempt to break a walking-stick by drawing it apart, while holding the ends.

Wiebiking states that a rise of 1 in 24 is a convenient ascent for a bridge. In timber bridges the settlement is 1 in 72: that is, if a timber bridge of 144 feet span rise one foot in the middle when first framed, it will settle so as to be horizontal; so that when it is intended for the bridge to have an ascent of 1 in 24 when finished, it must be framed so as to have a rise of 1 in 18: for $\frac{1}{18}=\frac{1}{24}+\frac{1}{72}$.

The Britannia Tubular Bridge is one of the most remarkable structures in the world, the design of the celebrated Architect, Sir R. Stephenson. This bridge is on the line of the Chester and Holyhead Railway, crossing the Menai Straits, within sight of Telford's Chain Suspension Bridge. It is made of cast iron of a tubular form, in the tube of which the railway passes. Four of these span the Strait, and are supported by piles of masonry; that on the Anglesey side is 143 feet 6 inches high, and from the front to the end of the wing walls is 173 feet. These wing walls terminate in pedestals, on which repose colossal lions of Egyptian character. The Anglesey pier is 196 feet high, 55 feet wide, and 32 feet long. In the middle of the Strait is the Britannia Rock, from which the bridge derives its name; on this the Britannia pier is raised. It is equally distant from the Anglesey and Caernarvon piers, being 460 feet in the clear from each, and sustains the four ends of the four long tubes, which span the distance from shore to shore. There are two pair of short and two of long tubes, the lengths of these pairs being 250 feet and 470 respectively. The Egyptian lions are 25 feet 6 inches long, 12 feet

6 inches high, 8 feet wide, and weigh 80 tons. Two thousand cubic feet of stone were required for each lion. The total quantity of stone in the bridge is 1,400,000 cubic feet. The weight of malleable iron in the tubes is 10,000 tons, of cast iron, 1,400 tons. The whole length of the entire bridge, measuring from the extreme front of the wing walls, is 1,833 feet, and its greatest elevation at Britannia pier, 240 feet above low-water mark. The total cost of the structure is £601,865.

The following observations refer to the arrangement of parts in ordinary bridging:

In the building of bridges, where piers are required in the stream for the support of the arches, it is important to place them as nearly as possible at right angles to the stream or current; and the piers should be made convex towards the stream, for their better resistance to floods. The position of a bridge, moreover, should not be in a narrow part, nor one liable to swell with tides or floods, inasmuch as the contraction of the waterway increases the depth and velocity of the current, and may thus endanger the navigation as well as the bridge itself. It is usual to construct bridges with an odd number of arches, and this on several accounts: among which are, that the stream being usually most powerful in the middle, an egress through that part is best provided for by having a central arch; and again, if the bridge be not perfectly horizontal, symmetry is gained by rising from the sides to the centre, and the whole roadway may be made one continued curve. When a bridge is equally high throughout, much saving of centring is made, because the arches being all equal, two sets of centres will be sufficient. If, however, the bridge be higher in the middle than at the extremities, the arches on each side the centre one must diminish similarly, so as to be respectively symmetrical; and by this arrangement beauty is gained, and the centring for one side equally suits the other. It is desirable to construct a bridge with as few arches as circumstances will allow, that there may be a free passage for the water, as well as for the vessels tha have to pass up and down, not to mention the saving of materials and labor where there are fewer piers and centres. When a single arch can be compassed, no more should be permitted. The piers should be of sufficient solidity to resist the thrust or push of the arch, independent of other arches, so that the centring of an arch may be struck without danger of overturning the pier left naked; and the piers should also be spread as much as possible on the bases, and diminish gradually upwards from their foundations. The method of laying the foundations in a river is now usually by means of coffer-dams, which are large inclosures, made by piling round the space to be occupied by the pier, so as to render it water-tight, and then pumping out the water, and keeping the space dry till the pier is built up to the ordinary level of the water; but if the ground about be loose, this method cannot be well practised, and recourse is had to caissons, which are a species of flat-bottomed boat, in which the pier is built up to a certain height, and then sunk over the place where it is intended to remain, the bed of the river being dredged out to receive it, or piles driven on which it may lodge when the sides of the chest or caisson are knocked away. In constructing the centres, great care must be taken to make them incapable of bending or swerving while the arch is being turned, otherwise the form of the arch will be crippled.

BRIMSTONE. (*See* SULPHUR.)

BRINE. (*See* SALT.)

BRITISH GUM. When starch is exposed to a temperature of about 600°, it becomes of a brownish color, and so far altered in its chemical character as no longer to form a blue color with iodine: it is also soluble in cold water. In this state it is used, under the above name, by calico printers.

BROMINE. (Gr. *βρωμος, a strong odor.*) An undecompounded substance, discovered in 1826 by M. Balard of Montpelier. In its general chemical habitudes it much resembles chlorine and iodine, and is generally associated with them. It exists, but in very minute quantities, in sea-water, and in the ashes of marine plants. It is usually extracted from *bittern* by the agency of chlorine. At common temperatures it is a very dark reddish liquid, of a powerful and suffocating odor, and emitting red vapor. Its specific gravity is about 3. It boils at 116°, and congeals at 4°. The density of its vapor is 5·5; 100 cubic inches at mean temperature and pressure weighing 167·25 grains. It is an electro-negative; it has bleaching powers, and it is very poisonous. Its equivalent number is about 78; it combines with hydrogen to form *hydrobromic acid gas*, 100 cubic inches of which weigh 84·7 grains. With oxygen it forms the *bromic acid.* Its combinations are termed *bromides;* they have not hitherto been applied to any use, but some of them are probably possessed of powerful medical qualities.

In this country bromine is obtained from the mother waters of the Salt Springs in the Valley of the Mississippi. Its chief use is in daguerreotyping, as an accelerator, to coat the silver plate, and aid the iodine in producing the image in a shorter period.

BRONZE. A material used for casting statues, groups, &c., in a mould similar in principle to that wherefrom all plaster casts are produced. From the extraordinary dimensions which involve the chief differences between the operations of casting in brass and plaster, much intelligence and care on the part of the sculptor is necessary to produce the fac-simile of the work on which his labor has been expended. The material employed for the purpose is a compound chiefly consisting of copper, tin, and other metals. The process of procuring the cast depends on circumstances requiring much nice arrangement.

Bronze is a compound metal, consisting of copper and tin, to which sometimes a little zinc and lead are added. The alloy is much harder than copper, and was employed by the ancients to make swords, hatchets, &c., before the method of making iron was understood. The art of casting bronze statues may be traced to the most remote antiquity: but it was first brought to a certain degree of refinement by Theodorus and Rœcus of Samos about 700 years before the Christian era, to whom the invention of modelling is ascribed by Pliny. The ancients were well aware that by combining copper with tin a more fusible metal was obtained, that the process of casting was therefore rendered easier, and that the statue was harder and more durable: and yet they frequently made them of copper nearly pure, because they possessed no means of determining the proportions of their alloy, and because by their mode of managing the fire, the copper became refined in the course of melting, as has happened to many founders in our own days. It was during the reign of Alexander that bronze statuary received its greatest extension, when the celebrated artists Lysippus succeeded by new processes of moulding and melting to multiply groups of statues to such a degree that Pliny called them the mob of Alexander. Soon afterwards enormous bronze colossuses were made to the height of towers, of which the isle of Rhodes possessed no less than one hundred.

The Roman consul Mutianus found 3,000 bronze statues at Athens, 3,000 at Rhodes, as many at Olympia and at Delphi, although a great number had been previously carried off from the last town.

In forming such statues the alloy should be capable of flowing readily into all the parts of the mould, however minute; it should be hard, in order to resist accidental blows, be proof against the influence of the weather, and be of such a nature as to acquire that greenish oxidized coat upon the surface which is so much admired in the antique bronze. The chemical composition of the bronze alloy is a matter therefore of the first moment. The brothers Keller, celebrated founders in the time of Louis the Fourteenth, whose *chefs d'œuvre* are well known, directed their attention towards this point, to which too little importance is attached at the present day. The statue of Desaix, in the Place Vendome in Paris, is a noted specimen of most defective workmanship from mismanagement of the alloys of which it is composed.

On analyzing separately specimens taken from the bas-reliefs of the pedestal of this column, from the shaft, and from the capital, it was found that the first contained only 6 per cent. of the alloy, and 94 of copper, the second much less, and the third only 0-21. It was therefore obvious that the founder, unskilful in the melting of bronze, had gone on progressively refining his alloy by the oxidizement of the tin, till he had exhausted the copper, and that he had then worked up the scoria in the upper part of the column. The moulding of the several bas-reliefs was so ill-executed that the chisellers employed to repair the faults, removed no less than 70 tons of bronze, which was given them, besides 300,000 francs for their work.

The alloy most proper for bronze medals, which are to be afterwards struck, is composed of from 8 to 12 parts of tin, and from 92 to 88 of copper; to which if 2 or 3 parts in the hundred of zinc be added, they will make it assume a finer bronze tint. The medal should be subjected to three or four successive stamps of the press, and be softened between each blow by being heated and plunged in cold water.

Bell-Metal. The bronze of bells, or bell metal, is composed in 100 parts of 78 copper and 22 tin. This alloy has a fine compact grain; is very fusible and sonorous.

The other metals sometimes added are rather prejudicial, and merely increase the profit of the founders. Some of the English bells consist of 80 copper, 10·1 tin, 5·6 zinc, and 4·3 lead; the latter metal, when in such large quantity, is apt to cause insulated drops, hurtful to the uniformity of the alloy. A little phosphorus is sometimes added with advantage.

The Chinese gongs are composed of 78 parts copper, and 22 parts tin. This alloy when newly cast is as brittle as glass, but by being plunged at a cherry-red heat into cold water, and confined between two discs of iron to keep it in shape, it becomes tough and malleable. The Chinese cymbals consist of 80 parts copper and 20 parts tin.

Common Metal consists of about 90 or 91 copper, and 9 or 10 of tin. Never less than 8 or more than 11 parts of tin in the 100 should be employed.

Speculum Metal. One part of tin and two parts (or more exactly 100 parts tin and 215 parts copper) form the ordinary speculum metal of reflecting telescopes, which is of all the alloys the whitest, the most brilliant, the hardest, and the most brittle. The alloy of 1 part tin and 10 of copper, is the strongest of the whole series.

The bronze founder ought to melt his metals rapidly, in order to prevent the loss of tin, zinc, and lead, by their oxidizement. Reverberatory furnaces have been long used for this operation, the best being of an elliptical form. The furnaces with dome tops are employed by bell founders, because their alloy being more fusible, they do not require so intense a heat; but they also would find an advantage in using a more rapid mode of fusion. The surface of the melting metals should be covered with small charcoal or coke, and when the zinc is added it should be dexterously thrust to the bottom of the melted copper. Immediately after stirring the melted mass so as to incorporate the ingredients, it should be poured out into the moulds. In general the metals most easily altered by the fire, as the tin, should be put in last. The cooling should be as quick as possible in the moulds to prevent the metals separating from each other in the order of their destiny, as they are very apt to do so. The addition of a little iron in the form of tin-plate, to bronze is reckoned to be advantageous.

Bronzing (of Objects in Imitation of Metallic Bronze). Plaster of Paris, paper, wood, and pasteboard, may be made to resemble pretty closely the appearance of articles of real bronze, modern or antique. The simplest way of giving a brilliant aspect of this kind is with a varnish made of the waste gold leaf of the beater, ground up on a porphyry slab with honey or gum-water. A coat of drying linseed-oil should be first applied, and then the metallic powder put on with a linen dossil. Mosaic gold ground up with six parts of bone-ashes has been used in the same way. When it is to be put on paper, it should be ground up alone with white of eggs or spirit varnish, applied with a brush, and burnished when dry. When a plate of iron is plunged into a hot solution of sulphate of copper, it throws down fine scales of copper, which being repeatedly washed with water, and ground along with six times its weight of bone-ashes, forms a tolerable bronze.

Powdered and sifted tin may be mixed with a clear solution of isinglass, applied with a brush, and burnished or not, according as a bright or dead surface is desired. Gypsum casts are commonly bronzed by rubbing brilliant black-lead, *graphite*, upon them with a cloth or brush. Real bronze long exposed to the air gets covered with a thin film of carbonate of copper, called by virtuosi antique *ærugo* (*patine antique*, Fr). This may be imitated in a certain degree by several applications skilfully made. The new bronze being turned or filed into a bright surface, and rubbed over with dilute acquafortis by a linen rag or brush, will become at first grayish, and afterwards take a greenish blue tint; or we may pass repeatedly over the surface a liquor composed of 1 part sal ammoniac, three parts of carbonate of potash, and 6 of sea salt, dissolved in 12 parts of boiling water, to which 8 parts of nitrate of copper are to be added; the tint thereby produced is at first unequal and crude, but it becomes more uniform and softer by time. A fine *green-blue* bronze may be obtained with very strong water of ammonia alone, rubbing it at intervals several times upon the metal.

The base of most of the secret compositions for giving the antique appearance is vinegar with sal ammoniac. Skilful workmen use a solution of 2 ounces of that salt in an English quart of French vinegar. Another compound which gives good results is made with an ounce of sal ammoniac, and a quarter of an ounce of salt of sorrel (binoxalate of potash), dissolved in vinegar. One eminent Parisian sculptor makes use of a mixture of half an ounce of sal ammoniac, half an ounce of salt, an ounce of spirits of hartshorn, and an English quart of vinegar. A good result will also be obtained by adding half an ounce of sal ammoniac, instead of the spirits of hartshorn. The piece of metal being well cleaned, is to be rubbed with one of these solutions, and then dried by friction with a fresh brush. If the hue be found too pale at the end of two or three days, the operation may be repeated. It is found to be more advantageous to operate in the sunshine than in the shade.

In bronzing plaster figures a cement may be used or not; if used, the bronzing will be more durable, the powders are mixed with strong gum water or isinglass, and laid on with a pencil. The subject may be covered with gold-size diluted with turpentine, and when nearly dry rubbed with a piece of soft leather.

Coins of copper and medals may be bronzed thus:—Dissolve in vinegar 2 parts of verdigris and 1 part sal ammoniac. Boil, skim, and dilute the solution with water until it ceases to let fall a white precipitate. The solution is then boiled and poured upon the objects to be bronzed, previously made perfectly clean and free from grease, the articles are then washed and dried.

A deposit of brass or bronze may be thrown on objects by the electrotype process, by employing a solution of 500 parts carbonate of potash, 20 parts chloride of copper, 40 parts sulphate zinc, 250 parts nitrate of ammonia.

For bronzing, a salt of tin is substituted for the zinc salt. By this solution, iron, cast iron, steel, lead, zinc, tin or their alloys are easily, coated with brass or bronze, by placing the article in contact with the negative pole of a Bunsen battery, and a plate of bronze or brass used as a positive pole.

BRUNSWICK GREEN. A pigment obtained by exposing metallic copper to the action of muriate of ammonia. It is a compound of chloride and oxide of copper. It is also generated by the action of sea water upon copper, as in the green matter which incrusts the copper sheathing of ships.

BUDE LIGHT. (*See* GAS).

BURETTE. An instrument occasionally used in the chemical laboratory, and in the assay office, for the purpose of dividing a given portion of any liquid into 100 or 1000 equal parts.

BUOYS. Vessels formed of wood, cork, or some light substance, moored or anchored so as to float over a certain spot, in order to indicate the situation of a shoal or sand-bank, and mark out the course a ship is to follow. When used for this purpose, buoys are usually close vessels in the form of a cone, of large dimensions, in order that they may be seen from a distance; and generally painted of some particular color, in order that they may be more readily distinguished from one another. Private buoys are used for the purpose of indicating the situation of ships' anchors (to which they are fastened by a rope), in order that the ship may be prevented from running foul of the anchor, and that the anchor and cable may be recovered when the latter happens to be broken, or has been cut.

BUTTER. The oil or fat of milk. The light matters suspended in milk separate in the form of cream, and this cream by churning becomes separated into butter and buttermilk. During this process the temperature of the cream is slightly raised, a little oxygen absorbed, and the acid produced: this change is not, however, essential to the separation of the butter which takes place when air is excluded and depends upon the rupture of the oil globules. It is naturally of a yellow color, and is deepened when cows are fed in rich pastures; and carrot juice and arnotto are often added to heighten the tint. The Tartars and French preserve butter by melting it in a water bath at a temperature of 176°, whereby the albuminous and curdy matters, which are putrescible, are coagulated. If it be decanted while liquid, strained and lightly salted, it may be kept fresh for years.

In November, 1849, a patent was granted to Mr. Elias H. Merryman, of Springfield, Illinois, for improvements in Butter-working Machines. His claim is the use of two or more rollers, with adjustable scrapers, held in contact with the rollers by springs, or other devices, operating in a vat of running water, to wash butter and separate the broken capsules, cheesy matter, buttermilk, and other impurities, by dissolving those that are soluble in water, and washing away those that are not soluble, substantially as described—the water being let into the vat from a cistern placed above the level of the vat, and escaping at the spout, on a level with the journals of the rollers.

According to the census return of 1845, the quantity of butter made in the State of New-York, was 79,501,770 pounds; which at twelve and a half cents a pound, would amount to $9,937,716. American butter, if well prepared, would find a ready sale in the English market.

The following, taken from the Patent-Office Reports of 1847, is the plan, in substance, pursued by Philip Physick of Germantown, who has taken the premium of the Philadelphia Agricultural Society for two or three years successively. In the first place, great attention is paid to cleanliness: the *tin* pans are put into a boiler and boiled for an hour, then scoured with white silver-sand and pure hard soap and rinsed in pure water, and then put away for use. The udders of the cows are washed for three days, and wiped with a clean towel. The milk is also drawn in tin pails, which have been cleansed in the same manner as the pans; it is strained through a perfectly clean muslin strainer, and put into the spring-house till four milkings are collected; then the whole milk and cream are thrown into a common barrel-churn, which has been rinsed with boiling water with a quarter of a peck of hickory ashes and live coals stirred about in it by turning the crank, and then thrown out and the churn rinsed several times with boiling water; the cows' udders are then washed and milked, and this milk strained and poured warm into the churn—the churning is done slowly, as the tenacity and hardness of the butter depends on this; it should take three hours. When the butter has come it is collected by a clean wooden ladle and laid on a clean linen cloth as flat as possible, not more than two inches thick. Next take a clean coarse cotton bag, which will hold a half peck or more, and fill it with ice, and with a mallet mash it down flat about four inches thick; place the cloth on it till it is hard; then on a clean white marble slab add finely pulverized salt to suit the taste, and work out the buttermilk with a wooden spoon and ladle; spread the butter flat again, and again sopping up the buttermilk with the linen cloth, which must however, be done very slowly. When it is free from all the buttermilk, make it up into pounds or half pounds.

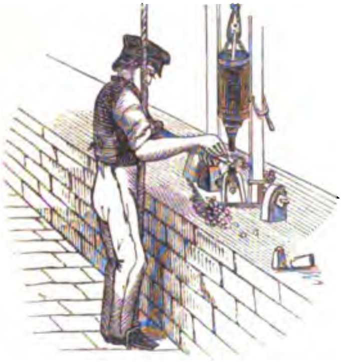
BUTTONS. The materials of which buttons are made are very various, and this variety gives rise to a subdivision somewhat akin to that which marks many other departments of manufactures. Besides the well known gilt buttons, plain and figured, there are plated, silk, florentine, and other covered buttons—pearl, horn, shell, bone, wood, glass, and porcelain buttons, and probably many others. The two latter-named varieties are made at the works where either glass or porcelain articles are manufactured; but the rest are produced chiefly at Birmingham, the different manufacturers producing their respective varieties.

The number of females to which the manufacture gives employment is very large, and the nimbleness with which most of the processes are carried on by them is truly remarkable.

We may first select a common gilt button, and follow it through its processes of manufacture. The material of which these are made is sheet copper, or a mixed metal of which copper is a component part. From these sheets, "blanks" or circular pieces are cut out, a trifling degree larger than the intended size of the button. This is done by means of small presses, of which there is a large number in every factory, devoted to one or other of the different kinds of button. The press for cutting the "blanks" has a circular cutter or punch, worked by a lever or handle; and a female holding a sheet of metal in one hand and the lever of the press in the other, cuts the blanks with surprising rapidity, shifting the copper after each cut in order to expose a new part of the surface, and causing the punch to descend after each adjustment.

Whatever be the form or nature of the button, this preliminary punching of the blank is almost always observed; but beyond this, many varieties occur. The common flat gilt buttons for coats are flat on both sides, and consist of but one thickness of metal, which is punched out in the form of a blank. But there are many kinds of livery buttons, small globular buttons for boys' dresses, and other kinds, which are convex on the outer surface; and this convexity has to be given to them after the blank is cut. Again, of those which are convex, some are of one thickness only, presenting at the back the concave side of the same piece of metal which is convex in front; while others (called "shell" buttons) are hollow, and made of two pieces of metal—one for the front and the other for the back. In this latter case, there are two blanks or circular pieces punched out separately; one called the "shell," and the other the "bottom." The shell, as well as convex buttons generally, is pressed to a convex shape by a machine similar in principle to the punching press, but having a curved polished surface to act upon the metal, instead of a punch. One female will stamp twelve gross in an hour, or nearly thirty per minute.

The rawness of the edge is removed by turning each button slightly in a lathe, to give regularity of surface.



To bring both parts of the shell button together, they are pressed in a die and punch, so peculiarly adjusted that the edge of the shell becomes bent over and lapped down upon the bottom, securing the two together in a way at once firm and neat without the employment of any solder, rivet, or other mode of fastening. The device, or letters on buttons, is given by steel dies, and a stamping press similar in construction with the wood-cut.

The *shank* of a button is in some respects more remarkable even than the blank, partly on account of its manufacturing arrangements—strange as they will appear to most persons. It might well be supposed that in large factories where five or six hundred persons are employed in making buttons, the production of the bit of twisted wire which forms the shank, would at least form one of the departments. Yet this is not the case: the button-makers are not shank-makers; the latter branch being carried on by a wholly distinct class of manufacturers, of whom there are three or four in Birmingham. The reason seems to be, that the machinery employed is so costly and intricate, and the value of each shank when made so extremely minute, that nothing less than making for a great many button-makers could pay for the maintenance of a regular establishment; so that the button-makers, as a body, can buy the shanks cheaper than make them.

Thus does the commerce of manufactures adjust and regulate itself, when left to seek its natural channels. The shanks are made of brass wire, and vary from eight to forty gross per pound weight. In the beautiful machine now employed for their manufacture, a coil of wire is so placed that one end gradually advances towards a point where a pair of shears cut off a short piece; a stud then presses against the middle of the piece, and forces it between the two jaws of a kind of vice in a staple-like form; the jaws then compress it so as to form the eye of the shank; a little hammer next strikes the end to make it level; and lastly, another movement enables the shank to drop into a box quite ready for use. Some English firms manufacture two hundred million shanks per year.

The blanks or body of the buttons being ready to receive the shank, they are handed over to workwomen who connect them. The button is laid flat, bottom upwards; the woman places the shank in the proper position with a piece of bent iron, like a spring clasp; she presses the shank tightly to the bottom, touching then the foot of the shank where it joins the bottom, with a little solder. When some hundreds are so adjusted, the whole are placed on an iron plate and exposed on an oven to a heat sufficient to melt the solder and unite the shank firmly to the button.

To cleanse the buttons, they are dipped twice in nitric acid, and let drain. To be silvered they are put in an earthen pan, containing a nearly dry mixture of silver, common salt, cream tartar, and some other ingredients, and well stirred up for a minute or two. This gives them a silver white color. The gilding is a more elaborate process. In some cases the gilding is only applied to the face, or *top gilding*; in others, to the whole surface, called *all-over* gilding. For the latter purpose the buttons are first pickled in dilute sulphuric acid, and then immersed in a solution of nitrate of mercury, which leaves a thin mercurial deposit over the whole surface. For top-gilding, the tops are laid on a board, and washed over with a brush. Five grains of gold will cover 144 one-inch buttons, and sometimes even half of that quantity is made to serve. A few grains of gold leaf dissolved in ten times its weight of mercury, is the amalgam used in gilding. This is gently heated in an iron ladle, and stirred with an iron rod; then poured in cold water, and finally strained through wash leather, to remove the superfluous mercury. This mass is then dissolved in dilute nitric acid, and the buttons either dipped in or washed with it. The next process is to drive off the mercury by heat. This is done by placing the buttons in a wire cage, within a furnace, framed to carry up and condense the mercurial vapors, and passing them into a vessel of water, to *polish* them. They are now removed to the lathe, and carefully burnished with bloodstone.

The florentine and silk buttons have now nearly superseded the gilt button manufacture. These contain each two circular bits of iron, a piece of thick pasteboard, another of canvas, and the outer silk or florentine covering. All these are cut out by stamping presses. The sheet of iron, of paper, of canvas, or of florentine, is shifted gradually till it is nearly all cut up into little discs.

The mode in which all the pieces are fixed together is very remarkable. There is no glue or cement, no riveting, no sewing, plaiting, twisting, or other modes of fastening; all being adjusted and fixed simply by stamping or pressure. Within the outer cloth cover is an iron casing called the 'shell,' within this is a disc of paper, then a disc of cloth, and at the back of all a disc of iron having a hole in the centre, through which some of the canvas is forced as a means for sewing the button on the coat or garment. All these are placed, in their proper order, in a kind of die or cell, and a descending punch, worked by a press, first fixes the cover to the shell, and then these two to the other three bits, curling up the edges of the two discs of iron in such a peculiar way as to enable them to clasp all the five bits firmly, and to hide all raggedness and imperfections of edge. The internal mechanism of the presses, to effect this, is beautiful and ingenious.

Some of the silk buttons have the iron 'shell' blacked with japan before being used; some are convex, while others are flat; some have a woven device in the centre of each, obtained by having the silk or other material woven expressly for the purpose, and by having each little disc marked out carefully by a separate apparatus to insure accurate punching; some have braided edges, produced by an additional number of pieces, and an additional complication of the stamping process; and, indeed, there are numerous modifications of the covered button which it would be difficult to particularize here; but the punching out of separate little discs, and the fixing of these by stamping or pressure, are the prevailing features of the manufacture among all.

White linen buttons, of a remarkably neat appearance, are among the novelties of recent times. They consist of a tin or white metal ring, over which a disc of linen is stretched like the parchment of a tamborine; and the beautiful manner in which the two are fixed together by a singular action of the press is very striking. The buttons made of bone, of horn, of wood, of mother-of-pearl, and of other materials, are generally the produce of other manufacturers, who work out their results by the aid of the circular saw, the lathe, the press, and a few other pieces of apparatus.

CABLE. The rope or chain by which the anchor of a ship is held. Cables, until within a recent period, were usually made of hemp, but of late years iron chains have come much into use. A hempen cable of 12 inches girth, and length 120 fathoms, weighs 3075 lbs. Since the weights of two cables of equal lengths will be as their sections, or squares of their girths, it is easy to deduce the following rule for the weight of any hempen cable:—Multiply the square of the girth in inches by 21·3 (or 21 nearly enough), the product is the weight in lbs. Since also as the breaking strain, or resistance against the force to part the cable, will be as the section, it will be as the weight, and will be found nearly by dividing the weight in lbs. by 100: the quotient is the breaking strain in tons. This rule is of course liable to great uncertainty from the quality or wear of the cable. Chain cables possess great advantages over hempen cables; they are not liable to be destroyed by chafing on rocky grounds, nor to become rotten and insecure from alternate exposure to the air and water; and by reason of their greater weight the strain is exerted on the cable rather than on the ship. In order that the ship may be enabled to let slip her cable in case of necessity, chain cables are furnished with bolts at distances from each other of a fathom or two, which can be readily withdrawn. A chain of which the section is 1 inch in diameter breaks with 16 tons; such a chain is equivalent to a 10 inch hemp cable nearly. And the dimensions of the chain cable corresponding to any hemp cable are therefore easily found by merely dividing the circumference of the hemp cable by 10. The strength of every part of the chain is proved before it leaves the manufactory.

CADMIUM. A white metal, much like tin. It fuses and volatilizes at a temperature a little below that at which tin melts. Specific gravity about 9. Its ores are associated with those of zinc. It was discovered in 1818 by Professor Stromeyer of Gottingen. Its equivalent number is 56. It forms a yellow salifiable oxide composed of 56 cadmium+8 oxygen=64 oxide of cadmium. Its scarcity prevents its employment in the arts, but the oxide has been used as a pigment, and the metal has been used in stopping teeth.

CAFFEINE. A bitter crystalline substance contained in coffee. It is volatile, and part of it is lost in roasting the berry. It is also found in tea, and in the ilex guaranensis of Brazil. It has not been applied in the arts to any useful purpose.

CAISSON. In architecture, a sunken panel in a flat or vaulted ceiling, or in the soffit of a cornice. In ceilings they are of various geometrical forms, and often enriched with rosettes or other ornaments. *Caisson*, in bridge building, is a large chest or vessel in which the piers of a bridge are built. This sinking as the work advances, its bottom at last comes in contact with the bed of the river, when the sides are disengaged, its construction being such as to admit of their being thus detached without injury to the floor or bottom.

CALAMINE. Native carbonate of zinc.

CALCINATION. The reduction of substances to cinder or ash. The term is derived from the Latin word *calx*, quicklime, which, as is well known, is prepared by the action of heat upon limestone; and hence the old chemists employ the word *calcination* to express any supposed analogous change, metallic substances being apparently converted into earthy matter by calcination.

CALCIUM. The metallic base of lime, discovered in 1808 by Davy. This substance has hitherto been obtained in such small quantities, that its properties have not been accurately investigated. It is probably a brilliant white metal, highly inflammable, and more than twice as heavy as water. Combined with oxygen it forms lime, which consists of 20 calcium+8 oxygen=28 lime. (*See* LIME.)

CALENDERING. The subjection of cloth and other articles to a machine, which, when so prepared, are *calendered*, literally meaning *hot-pressed*; by passing between cylinders or rollers it acquires a level or uniform surface. After goods are bleached and washed, they are twisted and tangled, so that they would not pass smoothly between the cylinders. They are previously passed over the surface of a water-cistern, and reaching the rollers in a damp state, they unfold themselves readily. The first pair of rollers over which the cloth is passed, does not dry or quite smooth it. The rollers in the calender are fixed in a vertical series in an upright frame, the rollers being pressed forcibly together by lever power. The lower rollers are generally grooved to remove creases; the upper rollers are smooth, and of wood and brass. In passing between these the cloth is smoothed and stretched, when it is wound upon a roller, ready to be starched.

The starch is made from flour, fermented and strained to separate the bran; a little indigo is added to give a blue tint, and the liquor thickened with porcelain clay, or calcined gypsum, to give apparent strength and thickness to the cloth, and make it more attractive to the purchaser. The starch is laid on by a stiffening mangle; the cloth first passing under a roller into a trough containing the starch liquor, becomes filled with starch, and then carried upwards, passes between rollers of brass and wood, tightly fitting against each other, by which the superfluous starch is pressed out, and falls down into the trough below. The cloth is then dried by being passed over tin or copper cylinders, heated by steam. Muslins are merely stretched on long frames to dry. The finish for cotton goods is generally by *glazing*, which gives a bright gloss to the material. In this case the cloth must first be damped, which is done by passing it over a cylinder, while a brush is at the same time scattering fine spray of water on the stuff. It is then passed between the rollers of the colors, and gets a silky lustre.

Copper-embossed rollers are occasionally used for producing figures and patterns on velvet goods. After the cloth has received its final gloss, it is smoothly folded on a clean board, and taken to be measured preparatory for sale. There are upwards of one hundred ways for making up goods. Muslin is made up in book-folds, in pieces of 24 yards; usually two half pieces are made up in one book. Cambrics and linens are in pieces 34 inches wide, and 8¼ yards long, folded up small, and tightly pressed. Handkerchiefs are sometimes folded in dozens.

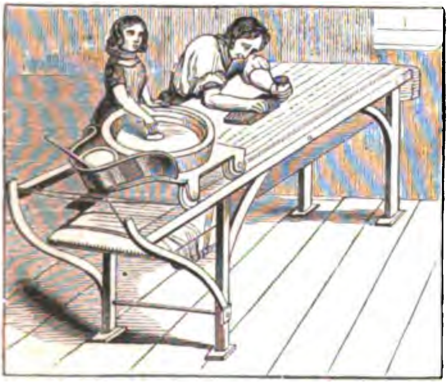
CALICO PRINTING. The art of producing figured patterns upon cotton by colored substances. Silk and woollen fabrics have been made of late years, subject to a similar style of dyeing. The fabric takes its name from Calicut, a district where it has been practised for many hundred years. The art of Topical dyeing was also known to the ancient Egyptians.

Before cloth can receive good colored impressions, it must be freed from fibrous down by singing, and be rendered smooth by the calender. They are next bleached, except those intended for Turkey-red; after being bleached, dried, singed, and calendered, they are lapped in lengths of several pieces, stitched together.

Four different modes are in use for printing figures upon calico: the oldest is by wooden blocks, on the face of which the design is cut, which are worked by hand. The wood-blocks measure about twelve inches by seven. They have a smooth surface of sycamore on a substratum of some commoner kind of wood: and the design, after being sketched on the block, is cut as in common wood-engraving, the parts being left prominent which are to constitute and print the pattern. In some patterns, where there are fine lines, the wood would soon be worn away, or brought to a defective state by use; and to obviate this, little slips of copper are inserted into delicate grooves cut for them, the copper slips all standing at an equal height, and forming the printing surface. Small pieces of felt are in some places introduced to fill up the interstices between the coppers, so as to imprint a broader patch of color.

One block can only print one color: and, therefore, if five or six colors form the design, and all be printed by blocks, there must be five or six blocks, all equal in size, but the raised parts in each block corresponding with depressed parts in all the other blocks. The principle involved is precisely the same as that displayed in floor-cloth printing.

Another method, quite of modern introduction, is somewhat analogous to stereotype printing. In the first place a model is formed from the design, comprising so much of it as may be included within a space of five inches long by an inch and a half wide. This model is formed of bits of metal inserted into a ground or block, and a mould is produced by stamping from the model. From the mould fixed in a block, and adjusted in a convenient way, stereotype pieces or copies are produced, in a mixed metal of tin, lead, and bismuth. When a number of these pieces are prepared, their surfaces are brought to a perfect level by means of a file, and they are then firmly fixed down upon a stout and carefully prepared piece of wood.

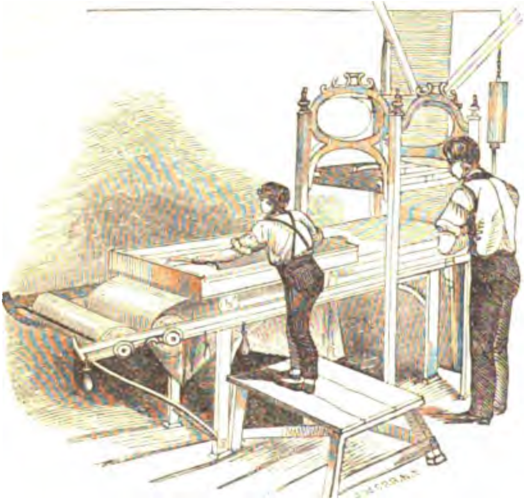


The block - printing room generally exhibits a number of machines similar to that in the cut.

The cloth wound off rollers, passes on the surface of the table to be printed, and, after printing, passes on to another roller, the printer regulating this movement. Each machine is besides attended by a boy and a girl: one of these dips a brush into the color-vessel, and spreads a layer on the elastic trough. The printer takes his engraved block by the handle on its back, and presses it on the trough, the elasticity of which allows every part of the raised device on the block to take up a layer of color, and then prints a portion of the cloth equal to the size of the block. There are small pins or guide-marks on the corner of the block, by which the printer is enabled to adjust each successive impress from the block. When the whole piece has been worked over with one block, the printer goes over the same piece with a second, perhaps with a third, and so on according to the number of colors in the design, a new block being used for every color.

Another mode of printing is that by which all the colors may be laid on at once by stereotype plates. A flat piece of wood is provided two or three feet square, on which are fixed all the stereotype pieces; those for one color are ranged in one row or stripe, five inches wide: those for another color form a second stripe, contiguous to and parallel with the first, and so on for the 3d, 4th, or 5th. The length of each stripe is equal to the breadth of the cloth, the whole forming a compound printing-block, divided in five compartments. These blocks are used in a printing-machine similar to type-printing: the block is fixed, face downwards, to the bottom of a descending frame, capable of receiving a vertical motion, and the cloth being laid on a table beneath, the block is brought down at intervals upon it, by means of a lever managed by the pressman. The color is laid on the block thus:

The boy has five troughs of color (or more) ranged before him; with a long piece of wood so formed as to dip in all these, and take up a small portion from each, he dabs it on a flat felt cushion; then with a brush he spreads these five colors in an equal number of patches over the surface of the felt, without combining or smearing one over the other. He next slides the cushion along a kind of railway till it comes underneath the block, which is made to descend upon it, and to imbibe a layer of color all over its surface, each one of the five rows of device falling upon one particular color on the cushion, without touching the others. The boy then draws out the cushion, and the man guides the block in its descent upon the cloth, which it imprints upon five different places in five different colors. All this is repeated a second time; but before the wetted block actually descends, the cloth has been made to shift about five inches lengthwise, or equal to the width of one row of the block. By this means each color falls upon a part which had been printed with a different color in the former descent. At each descent the cloth is shifted, so that each portion of the cloth is brought into contact with each of the five divisions of the block, and thus receives five different colors.

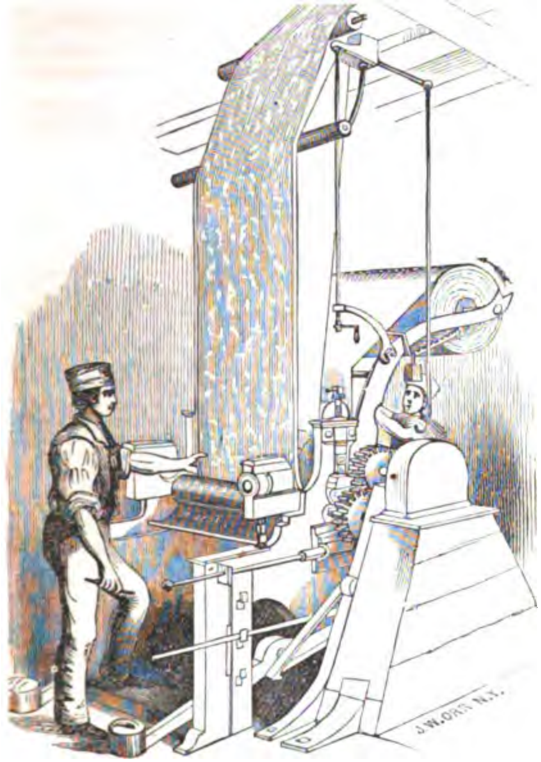


The illustration serves to convey an idea of this which is termed press printing.

The cylinder printing machine consists of an engraved copper cylinder, so mounted as to revolve against another cylinder lapped in woollen cloth, and imbued with a colored paste, from which it derives the means of giving colored impressions to pieces of cotton passed over it. The cylinder as it rotates dips in a long trough of color, and every part of it becomes coated. The excess of color has to be removed from the surface of the cylinder with a knife: this is called *doctoring*. The cloth then passes in a continuous strip between the cylinder and a large roller or drum above, by which it is pressed close so as to imbibe the color from the sunken device on its surface. As the cylinder is continually revolving while the cloth passes, the printing goes on uninterruptedly without stoppage or break. When a machine prints several colors, there are as many cylinders as colors required, each having a trough and doctor of its own, and the cloth passes in contact with each in turn.

Each cylinder machine prints a piece (28 yards) of cloth in a minute and a quarter, or three quarters of a mile per hour. In the subjoined illustration the cloth may be seen traversing the cylinder.

The economy of cylinder printing is very great. One machine with a man, and a boy to tend the color trough, being capable of printing as many pieces as 200 men and boys could do with blocks. A modification of cylinder printing is with wooden rollers cut in relief; it is called surface printing, the thick color being first laid on a tense woollen surface, and then transferred to the cylinder. When copper and wooden cylinders are combined in one apparatus, it has gotten the name of *union* printing. Having alluded to the mechanical operations, those which are chemical require now to be noticed.



If one hundred patterns of cotton require to be printed, nearly one hundred different modes of proceeding are necessary in the printing; for not only must the colors be different, but each color may perhaps require a peculiar groundwork to make it adhere to the cloth. Herein lie the delicacy and complexity of the calico-printer's operations; and hence arises a different chemical formula for almost every different pattern. Sometimes a piece of cloth is partially printed, then dyed, and then printed again; at other times the printing is effected at once; and at others a portion of the printing is to lay on color which is to be afterwards visible, while the other portion is merely to imprint the cloth with a chemical agent which shall exert some peculiar effect on the colors. This may perhaps be rendered intelligible by alluding to four different kinds of liquids or mixtures which are printed on the cloth by means of the cylinder, the press, or the block. These four are *colors*, *mordants*, *dischargers*, and *resists*. The name *colors* speaks for itself; it relates to the pigments or pastes which impart color to the cloth, and includes a very wide range of vegetable and mineral substances. A *mordant* is a liquid mixture which enables the coloring substance to combine permanently with the textile fibre; and this is used when the mordant has a combining affinity with the cloth as well as with the color, although the two latter, used singly, have no affinity for each other. Thus, if a red color were imparted to cloth by madder, it would wash out, or not be a "fast color;" but if the cloth were previously wetted with an aluminous salt, the madder color would be permanent. In most cases the mordant is a body of liquid, into which the cloth is immersed; but sometimes it is used in the same way as a paint or ink by the cylinder-machine. *Dischargers*, instead of being intended to fix the color to the cloth, are used to drive off or discharge the color after the latter is applied. This kind of chemical agent is used in combination with mordants, thus: the cloth is wholly saturated with the mordant, but certain parts are also printed with a discharger formed of lemon-juice or some other substance; the result of which is, that when the dye-color is afterwards applied, it combines with the cloth at the parts where the mordant has been unaffected, but becomes a "loose" color at the parts printed with the discharger, so as to be easily washed out from those parts. *Resists* are mixtures which enable the printer to produce white portions of pattern by a process rather different from the discharge-method. The mordant is printed, not dipped, in those parts which are to be colored in the pattern; while those which are to be kept white are previously printed with a mixture called a *resist* or *resist-paste*. The cloth is then wholly immersed in a dye-vat, but those portions which had been printed with the resist refuse to receive the dye, and hence remain white. It will be seen, therefore, that in "discharge work," as it is called, the white portions are retained by driving out the mordant, which would otherwise fix the color; while in "resist-work" the white portions are retained by shielding the cloth at those parts from the action of the color.

In calico printing it is necessary to bring the mordant or the color into that state of consistence that it will not spread in the cloth beyond the limit of the design. The usual mordants are alum or sulphate of alumina, acetate of alumina, peroxide of iron, protoxide of tin, and oxide of chrome: their solutions are made of the proper density by *thickeners*, such as wheat, starch, and flour; other thickeners are used, as gum arabic, British gum, gum senegal, tragacanth, jalap, pipe clay, dextrine, potato and rice starch, sulphate of lead, with gum, sugar, molasses, and glue. These with either the colors or mordants are prepared in vessels furnished with steam jackets.

The manner of applying a pattern on cloth is called a style: of these there are six.

1. The madder style.
2. Printing by steam.
3. The padding style.
4. The resist style.
5. The discharge style.
6. The china blue style.

The madder style is not confined to that color, but the process is applied to many others. In it the cotton is first printed with a mordant over those parts where it is desired to have a color produced. When the mordant has been laid on by the cylinder the cloth is hung up in a room for a few days, when the mordant has suffered an alteration whereby it becomes insoluble, and fastened into the fibre of the cloth. Any portion of the mordant which remains soluble has now to be removed, or the color when applied would pass beyond the pattern. It is removed by passing the dry calico through a warm mixture of cowdung and water. This operation is called dunging. It is then washed in water in a urine pit, and again in a dash wheel. By this process the thick paste is removed which accompanied the mordant. The difficulty of procuring cowdung in sufficient quantity has led to the employment of other substances, which are easily procured, and which are found on analysis to be the active agents in the dung: thus solutions of phosphate of soda and phosphate of lime, thickened with glue, are used under the name of *substitute* for this purpose. After washing in cold water, the cloth mordanted is rinsed through a weak solution of substitute and size, when it is ready for the color: this is laid on by drawing the cloth for two or three hours through a colored solution (*see* DYEING); the color attaches itself permanently to those portions of the cloth to which the mordant has been applied, and form a chemical compound with it. On the portions not mordanted the color is so feebly attached as to be removed by washing in soap and water, or in bran and water, or in a dilute solution of chloride of lime. This is called *clearing*.

The processes for finishing a piece of cloth, even with one color, are very numerous: thus if a red stripe be required on a white ground, no less than nineteen processes have to be passed through, viz.:

1. Printing on mordant of red liquor (acetate of alumina) thickened with flour, and dyeing. 2. Exposure of cloth till mordant is altered. 3. Dunging. 4. Wincing in cold water. 5. Washing at the dash-wheel. 6. Wincing in dung substitute and size. 7. Wincing in cold water. 8. Dyeing in madder. 9. Wincing in cold water. 10. Washing with dash wheel. 11. Wincing in soap water with a salt of tin. 12. Dash-wheel washing. 13. Wincing in soap water. 14. Wincing in a solution of bleaching powder. 15. Washing at the dash-wheel. 16. Drying by the water extractor. 17. Folding. 18. Starching. 19. Drying by steam.

From this it may be seen how important the washing and rinsings are.

In steam printing the mordant is first laid on and the cloth then dipped in the color vat: union does not however take place between the mordant and the color until steam is brought into contact with the cloth, when immediately the two unite. In some instances the cloth is hung in a room into which steam is admitted. In other, the goods are put in a box made almost steam tight and the steam admitted through a pipe perforated with a multitude of small holes; most commonly the cloth is wrapped round a cylinder perforated with holes into which the steam is admitted by a pipe. The temperature is kept at 212° to prevent condensation, which would make the colors run; a higher temperature is injurious. The steaming is carried on for half an hour or less according to the nature of the color. This gives a great brilliancy and delicacy of finish to the cloth. A variety of cheap goods are printedin fugitive colors; these, not being fixed by steaming or by a mordant, are called *spirit* or *fancy* colors: they wash off.

The padding style is only applied to mineral colors. The cloth is uniformly imbued with a color and then dried. This color is sometimes obtained by once dipping in the trough; at others it is necessary to dip the cloth first in one mineral solution and then in a second, when an insoluble color becomes fixed in the tissue; after each dipping the cloth is dried, or the cloth may be padded in one solution and afterwards winced in the other. To produce a design on a white or colored ground, the cloth is printed with one of the solutions and then padded or winced in the other. In the *resist* style the cloth is first printed with a resist paste to prevent the cloth from taking up the color when it passes through the dye bath. Some resists act mechanically, such as *fat* resists, these are used for silk; others act chemically, such as acetates of copper and lead, chlorides of zinc, and mercury, and arseniate of potash, thickened with gum, pipe clay, and oil. The discharge style, is that when a white or colored pattern is to be produced upon a colored ground. Here the mordanted cloth is printed with a substance called the *discharger*, which acts either on the coloring matter, or on the mordant, by converting them into colorless or soluble matters, which may be removed to allow the parts thus discharged to be died of another color. Vegetable and animal coloring matters are discharged by chlorine and chromic acid, and a mordant is usually discharged by an acid solution, such as lemon or lime juice, cream tartar, oxalic, citric, and weak sulphuric acids, thickened with gum or starch. In this way are produced the imitations of Bandana handkerchiefs, in which white figures are formed on a ground of Turkey red by means of a solution of chlorine, which is made to flow through the red cloth on certain points defined by the pressure of hollow lead types, inserted in plates of lead contained in a hydraulic press. This is furnished with pattern plates, one fixed on the upper block and the other on the lower, or movable plate. Fourteen pieces, previously dyed with Turkey red, are laid flat and smooth one on another, the whole is wound on a roller at the back of the press. The first yard is then unwound and laid flat on the slab of the machine. Then the workman turning a handle brings the pressure to act from a hydraulic machine, and the bed plate rises slowly till the cloth comes in contact with the upper horizontal plate; such is the power of the machine that the cloth is pressed between the two plates with a force of 300 tons. The chlorine liquor is then poured into the trough on the upper plate, and after remaining a short time is drawn off by a small cock, the pressure is removed and the bed plate sinks down; the cloth is now withdrawn and comes out diversified with white spots, which are as clearly defined on the lowest of the fourteen as on the top one. The red dye has here been immediately removed from the stuff by the chlorine; fifteen minutes is found to be a sufficiently long exposure. These white spaces are occasionally dyed of another color subsequently.

The *China blue* style is only practised with indigo. The bleached cotton is printed of the desired pattern with a mixture of indigo, orpiment, sulphate of iron, gum and water. It is then exposed to the air for two days and then stretched on a frame. This is immersed in three cisterns containing different liquids; 1st, in milk of lime; 2d, in a solution of sulphate of iron; 3d, in a solution of caustic soda. The frames are dipped several times alternately in 1 and 2. The dipping in No. 3 is less often, but follows immediately that into 2. The insoluble indigo which had been applied to the surface becomes converted into soluble indigo or *indigotin*, which is dissolved and transferred to the interior of the fibre when it is gradually precipitated in the insoluble form.

CALIPER COMPASSES, or simply Calipers, are compasses with curved legs, for measuring the caliber or diameter of cylinders, balls, or other round bodies. Calipers of the best sort are made with a scale having different sets of numbers engraved on it, like a sliding rule, for the purpose of exhibiting at once various relations depending on the magnitude of the diameter of the body measured. Thus, as the weights of balls of the same metal are in a constant ratio to the cubes of their diameters, the scale may be so graduated and numbered that the observer may read off either the diameter in inches, or the weight in pounds. Other numbers having a less immediate application are also frequently attached; for example, the degrees of a circle, the proportions of troy and avoirdupois weight, tables of the specific gravities and weights of bodies, &c. It is obvious that these may be varied infinitely, according to the purposes proposed to be accomplished.

CALOMEL. Protochloride of mercury, composed of mercury 10, chlorine 35. It may be made by rubbing mercury with corrosive sublimate, and applying heat to sublime the mixture; the white powder which rises is calomel: this is called *sublimed* calomel. Precipitated calomel is made by adding proto-nitrate of mercury in solution to a solution of common salt. Dr. A. T. Thompson has patented a mode of making calomel, by combining chlorine in the gaseous state with the vapor of mercury. Mr. Jewel prepares a finely divided calomel by passing its vapor into a room into which steam was admitted. It is one of the most useful of medicines.

CALORIMETER. An instrument for measuring the quantity of heat given out by bodies passing from one temperature to another.

CALORIMOTOR. This term has occasionaly been appllied to a peculiar form of the voltaic apparatus composed of one pair of plates of great extent of surface, the electricity of which, when transmitted through good conductors, produces intense heat. To Dr. Hare of Philadelphia, the philosophical world is indebted for the most powerful apparatus of this kind.

CALOTYPE is the name given by Mr. H. Fox Talbot to his improved Photographic method. The method of obtaining Calotype pictures is as follows:—Take a sheet of the best writing paper. Dissolve 100 grains of crystallized nitrate of silver in 6 ounces of distilled water. Wash the paper with this solution, with a soft brush, on one side, and put a mark on that side, whereby to know it again. Dry the paper cautiously by a distant fire, or else let it dry spontaneously in a dark room. When dry, or nearly so, dip it into a solution of iodine of potassium, of 500 grains to a pint of distilled water, and let it stay two or three minutes in this solution. Then dip it into a vessel of water, dry it lightly with blotting paper, and finish drying it at a fire, or spontaneously. All this is best done by candlelight. The paper so prepared the author calls *iodized paper*. It is scarcely sensitive to light; nevertheless it ought to be kept protected from the light. Shortly before this paper is wanted for use, wash a sheet of it with this liquid: Dissolve 100 grs. of crystallized nitrate of silver in 2 oz. of distilled water; add one sixth of its volume of strong acetic acid: let this mixture be called A. Make a saturated solution of crystallized gallic acid in cold distilled water; the quantity dissolved is very small; call this solution B. When a sheet of paper is wanted for use, mix together the liquids A and B in equal volumes, but only mix a small quantity of them at a time, because the mixture will not keep long without spoiling; call this mixture the *gallo-nitrate of silver*. With it wash the *iodized paper* on the marked side, by candlelight. Let the paper rest half a minute, and then dip it into water, Then dry it lightly with blotting paper, and at a distance from the fire. The author has named the paper thus prepared *Calotype paper*, on account of its great utility in obtaining the pictures of objects with the camera obscura. If this paper be kept in a press, it will often retain its qualities in perfection for three months or more, being ready for use at any moment; but this is not uniformly the case. It is best used a few hours after it has been prepared. The *Calotype paper* is sensitive to light in an extraordinary degree, which transcends a hundred times or more that of any kind of photogenic paper; it will take an impression from simple moonlight not concentrated by a lens.

Use of the Paper.—Take a piece of this paper, and having covered half of it, expose the other half to daylight for the space of *one second* in dark cloudy weather in winter, when there will be a strong impression upon the paper, but latent and invisible, and its existence not to be suspected by any one. To make it visible wash the paper once more with the *gallo-nitrate of silver*, and then warm it gently before the fire. In a few seconds, the part of the paper upon which the light has acted begins to darken, and finally grows entirely black, while the other part of the paper retains its whiteness. This paper is well suited to receive images in the camera obscura. When the aperture of the lens amounts to one third of the focal length, and the object is very white, as a plaster bust, &c., *one second* is sufficient to obtain a pretty good image of it, made visible by washing and warming.

The Fixing Process.—First wash the picture with water, then lightly dry it with blotting-paper, and next wash it with a solution of *bromide of potassium*, containing 100 grains of that salt dissolved in eight or ten ounces of distilled water. After a minute or two it should be again dipped in water, and then finally dried. The picture is in this manner very strongly fixed; and with this great advantage, that it remains transparent, and that, therefore, there is no difficulty in obtaining a copy of it. The Calotype picture is a *negative* one, in which the lights of nature are represented by shades; but the copies are *positive*, having the lights conformable to nature. A *negative* calotype may serve to furnish several *positive* ones, but after a while it grows faint; but it may be restored by washing by candlelight with gallo-nitrate of silver, and warming. A second series may now be taken.

CALP. Argillaceous limestone, containing sulphuret of iron and vegetable matter.

CAMBRIC. Very fine white linen, first made at Cambray, in Flanders, whence its name.

CAMEL. A machine invented by the Dutch for carrying vessels into harbors, where there is not a sufficient depth of water. It consists of two large boxes, or half ships, built in such a manner that they could be applied on each side of the hull of a large vessel. On the deck of each part of the camel a number of horizontal windlasses were placed, from which ropes proceeded on one side, and being carried under the keel of the vessel, were attached to the windlasses on the deck of the other part. When about to be used, as much water as necessary was suffered to run into them; all the ropes were then cast loose, and large beams were then placed horizontally through the port-holes of the vessel, the ends resting on the camels alongside. When the ropes were made fast, and the vessel properly secured, the water was pumped out, on which the camels rose and bore up the vessel.

A ship drawing 15 feet can be made by one of these to draw only 11 feet. The length of one of these camels was 127 feet, and the greatest breadth 22 feet.

CAMLET, or CAMBLET. A light stuff, of several varieties. Some are made of goat's hair; in some the warp is hair, and the woof hair or silk: others entirely of wool, or a warp of wool and a woof of thread. Camlets may be striped, watered, and figured.

CAMPHENE. One of the hydrocarbons, composed of 10 atoms of carbon and 8 atoms of hydrogen. It is identical with oil of turpentine. Camphor may be looked on as its protoxide—a term applied to one of the numerous fluids used for illumination: it is made of one part of oil of turpentine, mixed with about twelve parts of alcohol, and then distilled.

CAMPHOR. The produce of the camphor laurel of Japan and China. The roots and wood chopped small are boiled with water in an iron vessel, to which an earthen cap, filled with straw, is fitted. The camphor sublimes, and is condensed upon the straw. There are two kinds of camphor; 1, the Dutch or Japan camphor; and 2, the crude or China camphor. The first is the finest quality. Crude camphor resembles moist sugar before it is refined. This process is carried on in thin glass globes, which are filled with crude camphor, with a little bone-black and quick-lime. The globe is then placed on a water bath, and boiled. The camphor rises and sublimes upon the upper part of the vessel. When the sublimation is completed, the vessel is cracked by pouring cold water on it while hot, and the cake of camphor is removed. Camphor ($C^{10}\,H^{8}\,O$) is a white and semi-transparent solid of a crystalline fracture, and warm pungent taste. It is soft and tough, and not easily powdered, until mixed with spirit of wine. It evaporates in the air, and in phials at ordinary temperatures, and attaches itself to the surface most exposed to the light.

Camphor floats on water, and rotates rapidly if the water be clean; if the surface be greasy, the phenomenon will cease. It fuses at 347°, and boils at 400°, is sparingly soluble in water (about 5 grains in a pint) but readily in alcohol, ether, sulphuret of carbon, a few volatile oils, and other substances. It is used as a stimulant, both externally and internally, but it is a powerful poison. It is also used in some varnishes.

CAMPHORIC ACID. Obtained by boiling camphor in nitric acid; its composition is $C^{10}\,H^{7}\,O^{3} \times H\,O$.

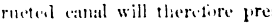
CAMWOOD. A red dye wood, obtained from Sierra Leone. Its coloring matter differs but little from Nicaragua wood.

CANAL. An artificial channel filled with water, formed for the purpose of draining, irrigation, supplying towns with water, or of inland navigation. The Cayuga Canal, which drains the marshes at the head of the lake, and empties into the Ontario Lake, is an illustration of the first. Those of Ancient Egypt are the best instances of the second. The supplying stream from the Croton river to the receiving basins in New York, illustrates the third. It is to the fourth kind, that for inland navigation, that the term is now almost wholly restricted.

There is no country in the world where the advantages of canals are more appreciated than in China. From time immemorial the rivers that intersect that vast empire have been united by innumerable canals; and the Grand Canal is said to be the most stupendous work of the kind that has ever been executed. Russia, too, exhibits a remarkable degree of enterprise in the construction of canals for the purpose of inland navigation; and though innumerable difficulties peculiar to that country for a long period impeded the progress of works of this description, that empire is now traversed by an unbroken line of water communication from St. Petersburg to the Caspian Sea.

The section of a canal is usually a trapezium, of which two sides are parallel and horizontal, and the other two equally inclined to the horizon. The inclination depends on the nature of the soil. It is least in tenacious earth, and greatest in loose soil; but no soil will maintain itself unless the base of the slope exceeds its height at least in the ratio of four to three. In loose soils the base requires to be twice as great as the height.

A canal is usually confined between a bank on one side, and a towing path on the other, the breadth of whose upper surface must be sufficient for a road on which the animals employed in draught may easily pass. This requires the breadth of the upper surface to be at least 9 feet. The usual mode for the other bank is to make the breadth at top equal to the height, measured from the bottom of the canal: but in this case there should be a *berm* of a foot, or a foot and a half, at the level of the water, which increases the thickness of the bank at bottom, and prevents the wash of the banks from falling into the canal. To prevent the entrance of rain-water, a *counter-ditch* is formed on the outside of each of the banks. The form of a well-constructed canal will therefore present the following figure:—



The dimensions of navigable canals must depend on the size of the vessels intended to navigate them. In order that they may enable two vessels to pass each other with freedom, the breadth at bottom is usually made twice as great as the breadth of the beam of the vessels; the depth requires to be at least one foot more than the vessel's draught of water.

The bed of a canal must be absolutely level, or have no more slope than is necessary to convey water to replace that which has been wasted. Hence, when a canal intersects a sloping country in a series of channels at different levels, means must be provided to enable vessels to pass from one level to another. This is commonly effected by means of a *lock*.

The invention of locks as a means of carrying a canal through an undulating country has given an entirely new feature to the inland navigation of Europe. Various nations have claimed the honor of this invention; but it would appear that the controversy which has arisen on the subject is not yet settled. A lock is a chamber, formed of masonry, occupying the whole bed of the canal where the difference of level is to be overcome. This chamber is so contrived that the level of the water which it contains may be made to coincide with either the upper or lower level of the canal. This is effected by two pairs of gates, one of which pairs is placed at each end of the chamber of the lock. By this means, while the gates at the lower end of the chamber are opened, and those at the upper end are closed, the water in the chamber will stand at the lower level of the canal; and on the contrary, when the lower gates are closed, and the upper ones are opened, the level of the water in the lock will coincide with the level of the water in the upper part of the canal. In the first case, a boat may be floated into the lock from the lower part of the canal; and if then the gates be closed, and water is admitted into the lock from the upper level unite the surface of the lock is in a line with the water above, the boat will be floated up, and on the opening of the upper gates may be passed onward. By reversing the course of procedure, boats may be as readily conveyed from the upper to the lower level. (*See* LOCK.)

The supply of water required for maintaining a canal depends on the *lockage* or quantity wasted in passing a vessel through the locks, on the evaporation from the surface, and on the leakage. It has been found by experiment that the annual quantity of evaporation from the canal of Languedoc is 32 inches; that is to say, the body of water required to supply this waste is equal to a parallelopiped whose base is the whole surface of water in the canal, and whose altitude is 32 inches: in most calculations it has been customary to take this altitude at 36 inches. With respect to the leakage, when the soil is porous the inner surface of the banks may be lined with an earth retentive of water, or a portion of the middle of each bank may be built up with earth of this character. The operation of lining a bank with clay, or earth retentive of moisture, is called *puddling*.

The advantages derived from canals are now so generally known and acknowledged, as to render it almost superfluous to allude to the question. The beneficial effects of canals are felt in a greater or less degree by all classes of society: by their means the manufacturer is enabled to collect his materials and his fuel with less labor and expense; the farmer obtains a supply of manure at a cheap rate, and a ready conveyance of his produce to the most profitable market; and the merchant is enabled to extend his commerce by exporting greater quantities and varieties of goods from places remote from the sea, and by more easily supplying a wider extent of inland country with articles of foreign produce. In short, general arguments in favor of canals are superseded by the rapidly improving and thriving state of all the cities, towns, and villages in their neighborhood; while the great works of every kind to which they have been conducted, and to which a large portion of them owe their rise, are their best recommendation. Experience has shown that the formation of railroads does not yet supersede the necessity for canals, as where cheapness, and not expedition, is required, the canal will be preferred. The general introduction of steam propulsion on our canals would be of great service. It has been tried on the Erie, and Chesapeake, and Ohio Canals.

CANDLE. Candles can be made from any fatty substance which, at ordinary temperatures, is in a solid state; wax, spermaceti, and tallow being the usual substances employed. That very essential part of a candle, the wick, performs an office which involves a scrap of philosophy not always well understood. The wick is composed of a dozen or more fibres of soft cotton, ranged side by side, and having just sufficient twist given them to make them cling together. The threads are not so close together but that oil, or tallow in a melted state, will ascend between them, by virtue of that capillary attraction which will cause a piece of loaf-sugar to become wet throughout, if placed on a wet spot. When a candle is lighted, the heat melts the upper part of the tallow, which then ascends between the fibres of the wick, and furnishes minute streams of combustible matter as fast as the oxygen of the air will consume it in the form of flame. The current of air constantly supplying oxygen, keeps the outer surface of the tallow cool, and causes the formation of the cup which contains the melted tallow that otherwise would run down and disfigure the candle: the tallow is the combustible matter, and the wick is the series of tubes through which it ascends to the flame. *Wax candles* are made by pouring melted wax over the wicks, which for the convenience of turning and placing them successively over the caldron, are usually attached to the circumference of a hoop; when of a proper thickness, they are rolled smooth upon a table, and the ends are cut and trimmed. It is in consequence of this method of manufacture, that when we cut a wax candle we observe it composed of successive layers or coats. Attempts have been made to cast wax candles in moulds, but those which are thus made never burn so well as those which are *poured*. *Spermaceti candles*, are mixtures of wax and spermaceti. This material forms a very good and cleanly candle; but in consequence of its ready fusibility and hardness when concrete, it does not admit of being carried about without spilling the melted material. The fused portions also, which run down the candle, are apt to curl and fall upon the table. *Composition candles*. This term was originally conferred by a manufacturer who had a large stock of spermaceti candles on hand which were of a dirty hue, and which therefore were unsalable; he advertised them under the above name, and they were soon disposed of, under the notion of their being composed of some new combination of materials. The term has since been applied to various mixtures; but what are now sold under the name of composition candles are chiefly mixtures of spermaceti, tallow, and a little resin, and occasionally wax. *Tallow candles*, which are either cast upon the wick in pewter moulds, or made by dipping the wicks, attached in rows to proper frames, into melted tallow. *Stearin candles*. Under this term we may include cocoa nut oil candles, and a few others made of the stearine, or what may be compared to the *spermaceti* of the vegetable oils. The stearine, or rather the *stearic acid* of tallow, is also now extensively employed for making candles. *Mould candles* are made in two ways. 1. From ten to sixteen cylindrical pewter moulds are placed together in a wooden frame, so that their upper ends terminate in a kind of trough common to the whole. The wicks are inserted and kept firmly in their proper places in the centre of each cylinder by strong wires. The frame being then placed with the trough uppermost, the moulds are filled with melted tallow, and are placed in the air to cool, after which the wires by which the wicks have been fixed are withdrawn, the superfluous tallow is removed from the trough, and the candles are pulled out of the moulds.

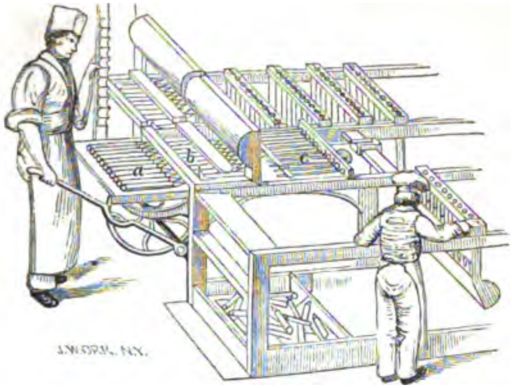
In the following illustration of a mould candle machine, *a* represents the candle, *b* the mould through which the candles are pushed by the rod *c*.

Messrs. Mattewson, candle manufacturers of Baltimore, have introduced a new English patent machine for making candles, which is both ingenious and possesses uncommon merit in an economical point of view.

It consists of a number of moulds, holding 18 each, which are furnished with a bobbin to each mould, holding wick for over 100 candles on each bobbin.

At the commencement, the first mould is threaded by hand. It is then placed on a railroad and brought under a cistern from which it is filled with tallow: it is then shoved along to a carriage, which, when it has received its load, is conveyed by rail outside to an open shed in the yard, where it is allowed to cool. When that operation is completed it still continues its circuit on the railroad, until it arrives at the machine, upon which it is placed, and a stroke of a lever ejects the whole 18 candles, at the same time threading the moulds for a fresh charge; a revolving saw-knife cuts off the wicks as quick as the hand can move it across the machine; the ends of the wicks are seized by pincers, which grip each of them as a person would with the finger and thumb; it is again placed on the rail and continues its course to undergo the same operation. On their way over the rail they are interrupted by a person who removes the pincers and trims the butt-ends of the candles.

Mr. A. L. Brown of New Haven, Conn., took out a patent in October, 1849, for an



improved moulding apparatus. The improvement in this apparatus consists in constructing the mould with a screw on the upper part, about two inches from the end, for adjusting and securing it in the frame, and a shoulder near the upper end, to support the tallow table, and a hole to admit the wire which supports the wick; also in attaching all the wires which support the wicks to a slide worked by a jointed wire handle, and governed by a guard, so that all the wicks may be evened by one motion of the hand, and then be all centred by another motion; also in using a smooth tallow table, level with the tops of the moulds, to allow the tallow to be easily scraped off and the whole kept clean.

Fig. 1, is a side-view of one of the moulds, showing the screw by which

FIG. 1.

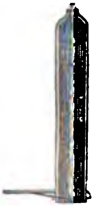
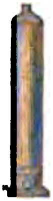


FIG. 2.



it is to be adjusted and secured in the frame; the shoulder on which the tallow table rests, and the hole through which the wire passes. Fig. 2, is a sectional view of one of the moulds, showing the wick when in the mould, as supported by the wire.

Great care is requisite in selecting the cotton for the wicks of candles, which should be of such a nature as to leave no ash, or scarcely any, when burned. The wick is occasionally impregnated with different substances, and sometimes so platted as to curl out of the flame. The following table contains the results of some experiments made by Dr. Ure, with a view of ascertaining the relative intensities of light and the duration of different candles:

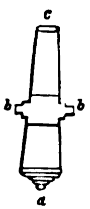
Number in a pound.	Duration of a candle.	Weight in grains.	Consumption per hour in grains.	Proportion of light.	Economy of light.	Candles equal to one Argand.
10 Mould	5 h. 9 m.	682	132	12.25	68·0	5·70
10 dipped	4 36	672	150	13.00	65·5	5 25
8 Mould	6 31	856	132	10.50	59·5	6 60
6 Ditto	7 2¼	1160	163	14.66	66·0	5·00
4 Ditto	9 36	1787	186	20.25	80·9	3·50
Argand oil flame		. .	512	69,40	100·0	

In reference to the above table, it appears from Dr. Ure's experiments that one-eighth of a gallon of good oil, weighidg 6,010 grains, or 13 and 1-10th ounces avoirdupois, lasts in a bright argand lamp 11 hours 44 minutes. The weight of oil it consumes per hour is equal to four times the weight of tallow in candles eight to the pound, and 3 and 1-7th times the weight of tallow in candles six to the pound; but, its light being equal to that of five of the latter candles, it appears from the above table, that two lbs. weight of oil, value one shilling (sterling), in an argand lamp, are equivalent in illuminating power to 3 lbs. of tallow candles, which cost about three shillings, sterling. The larger the flame in the above candles, the greater the economy of light. In reference to the comparative cost of coal gas, oil, tallow, and wax, it appears that the cost of a lamp fed by gas, and giving the light of about seven candles, will be about one penny sterling per hour; of an argand lamp, fed with spermaceti oil about threepence, of mould candles about threepence-halfpenny, and of wax candles about one shilling. Ninety cubic feet of good coal gas, value about one shilling sterling, will produce the light of about ten wax candles for one hour.

CANE MILL. (*See* SUGAR, MANUFACTURE OF.)

CANNELL COAL. (Perhaps *candle* coal, from the flame with which it burns.) A species of coal found in most of the English collieries, especially at Wigan in Lancashire. It is difficultly frangible, does not soil the fingers; when burning it splits and crackles, but does not cake, and leaves 3 or 4 *per cent.* of ash. It is sometimes worked into ornamental utensils, like jet.

CANNON. A military engine for projecting balls, shells, &c., by the force of gunpowder. The principal parts of a cannon are: 1. The *breech*, which is the solid metal from the bottom of the bore, or concave cylinder, to the extremity of the *cascabel*, *a*. 2. The *trunnions*, *b b*, which project on each side, and serve to support the cannon in equilibrio, their axis being in the vertical plane passing through the centre of gravity, but intersecting it below that point. 3. The *bore* or cylindrical cavity. This in several sorts of cannon is made of smaller diameter towards the breech, thus assuming the shape of two cylinders, united by a portion of a spherical surface. The smaller part of the bore is of such a length as to receive the maximum service charge of gunpowder, and is called the *chamber*. The entrance of the bore, *c*, is called the mouth or muzzle.



Cannon are made either of cast iron or brass, the latter being an alloy of copper and tin, in the proportion of about 10 parts of copper to 1 of tin, and called gun-metal. This has a greater tenacity than iron, but is objectionable on account of its greater density and higher price, besides being liable in rapid service to soften and droop at the muzzle, whereby it is rendered unserviceable. Since the advantage of using smaller charges of gunpowder was discovered, cast iron, though possessing less tenacity than gun-metal, has been substituted for ship, garrison, and battering guns. But the smaller species of cannon (field-pieces) continue to be made generally of brass: for by reason of the rapid cooling of the iron in small masses its strength is considerably impaired, so that it is difficult to be procured of the requisite quality.

Cannon were formerly cast with a cave or hollow, but they are now always cast solid; experience having shown that when cast solid they are stronger, and less liable to burst, that the metal is freer from honeycombs, and that the bore can be rendered more perfect, and its axis made to coincide more accurately with that of the piece. In boring cannon, the gun itself is made to revolve about the bit or borer, the size of which is successively increased.

CANNON-METAL. Bronze; a copper alloy.

CANVAS. A very clear unbleached cloth of hemp or flax, woven regularly in little squares, chiefly used to make sails for shipping. Besides serving for various domestic purposes, such as for the ground of tapestry work, canvas forms the cloth on which painters usually draw their pictures.

A kind of canvas made solely from hemp, and called *huckaback*, is used for coarse towels and table-cloths.

CAOUTCHOUC. This curious substance is the inspissated juice or sap of several plants; the principal supplies are from South America and Java, and are derived from the *Siphonia elastica* (Hevea caoutchouc), and probably from other Euphorbiaceous plants. It is often termed *gum elastic* and *India-rubber*. Its general properties and uses are well known. Among its more recent applications are those of elastic wove fabrics, formed of caoutchouc stretched into threads and covered with cotton; and various waterproof clothing, which is made by interposing a layer of caoutchouc between two folds of the cloth, and then forcibly uniting them by pressure. For this purpose the caoutchouc is dissolved by coal naphtha, and in that state brushed over the surfaces which are to be united.

Caoutchouc is a compound of carbon and hydrogen; when heated it fuses, and afterwards remains viscid. When subjected to destructive distillation at a high temperature, it yields 4-5ths of its weight of a highly inflammable and very light volatile oily liquid (hydrocarbon), which has been called *caoutchoucine*, and which is a good solvent of the unaltered caoutchouc. Washed sulphuric ether dissolves caoutchouc, and it is also soluble in several essential oils; but of these latter solutions the greater number leave it in a sticky state on evaporation.

The trees have incisions made into them through the bark; the milky juice exudes, is collected on clay moulds, dried in the sun, or with the smoke of a fire, which blackens it. The juice itself is a pale yellow, creamy liquid, which is miscible in water; it dries off into caoutchouc, and loses 55 per cent. Caoutchouc is insoluble in alcohol, but is soluble (besides ether), in naphtha from coal, oils of sassafras and lavender, and linseed oil. It melts at 248°, and burns with a bright flame and much smoke. It is not acted on by caustic potass, cold sulphuric acid, nor nitric acid, unless very concentrated. From its great elasticity it has been used in articles of dress and machinery. (*See* Elastic Bands.)

The India-rubber manufacture is one of the most important branches of art, rivalling that of some of the older textile fabrics. In this country it has made prodigious strides within a few years. The India-rubber shoes are made by women on the Amazon, by dipping the lasts, sent there from this country, into the juice of the tree, and then holding the last over a palm fire to dry it off quickly; the last is then dipped again in the milk, and again dried, and so repeated till it acquires the due thickness; this is completed in five minutes. Two gallons of milk suffice for ten pair of shoes. The shoes are then sun-dried, and next day stamped with pointed sticks, or the spines of the palm. The shoe is then cut from the last, and is ready for packing.

From its softness and impermeability it is made into bougies, catheters, gas-tubes, and bottles. Its use as a varnish is almost endless, dissolved in any of the solvents previously mentioned, or in bisulphuret of carbon, without the use of heat. This constitutes Parker's patent solvent. Chloroform is an excellent solvent, but it is too costly. By digesting the rubber in solution of carbonate of soda, or water of ammonia, previously, it dissolves more readily.

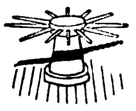
India-rubber is now rarely used alone in manufacture, but is previously mixed with other matters, which do not to any great extent affect its elasticity, or its waterproof properties. By mixing in sulphur when the rubber is in a semi-fluid condition it is said to be *vulcanized*, but as this gives an unpleasant odor to the fabric, various improvements have been made to obviate it. Patents have been taken out to use the hyposulphites, either alone or combined with sulphites and sulphurets. The sulphuret of antimony has been used with advantage. In another patent the rubber after being steamed and dried is *thionized*, which consists in submitting the mass to the action of the fumes of sulphur or sulphurous acid, by which the sulphur becomes incorporated. For manufacture the rubber is now never prepared by solution in turpentine or other menstruum; but it is reduced into a pasty mass by heavy grinding, and then passed through a succession of rollers until it is brought into sheets of uniform texture.

CAOUTCHOUCINE. A volatile hydrocarbon obtained by distilling India-rubber in an iron vessel at 600° Fahr.: it is purified by rectification, when it is colorless, and has a sp. gr. of 680. This liquid is a solvent for caoutchouc, copal, and very many resinous and oleaginous bodies when combined with alcohol. In the liquid state it is the lightest liquid known, but its vapor is so heavy that it may be transferred from one vessel to another by simple pouring. The liquid is very volatile, mixes readily with oils, and renders viscid oil paint liquid. Its constitution is $C^8 H^7$.

CAPERS. The buds or unexpanded flowers of the *Capparis spinosa*, in common use as a pickle.

CAPSICUM. The berry or seed-vessel of different species of capsicum. The larger pods of the *Capsicum annuum*, and the smaller ones of the *C. baccatum* or *bird pepper*, when powdered, form the *Kyan pepper* of commerce, so well known as a powerful condiment, and often useful as a stimulating medicine. Kyan pepper is often grossly adulterated with common salt, and occasionally red lead and earthy powders are said to be added to it: it often has a disagreeable rancid odor, owing to its being sprinkled with oil to prevent its dust affecting those who powder and sift it.

CAPSTAN, sometimes called CAPSTERN. A strong massive piece of timber, in the form of a cylinder or truncated cone, round which a rope is coiled; and being turned by means of bars or levers, it affords an advantageous mode of applying power to overcome an obstacle. The capstan is chiefly employed in ships, where it is used for weighing anchors, hoisting sails, &c. It is generally placed vertically, the lower end being let down through the deck of the



ship, and the levers inserted in holes in the head or top; so that the force of the men can be exerted continuously, and that there may be no necessity for removing the levers from one hole to another, as is the case when it is placed horizontally. The power of the capstan may be greatly increased by adapting an arrangement of wheel work to it—an improvement which has been adopted for several years past in the navy.

Improved forms of capstan have been patented in this country within the last few years.

CARAT. A weight used by goldsmiths and jewellers. Originally the Kuara bean was used for this purpose—hence the name. A carat is a weight of 4 grains, used in weighing diamonds. The term carat is also used in reference to the fineness of gold, in expressing which the mass spoken of is supposed to weigh 24 carats, of 12 grains each; and the pure gold is called *fine*. Thus, if gold be said to be 22 carats fine (or standard), it is implied that 22-24ths are pure gold, and 2-24ths alloy. In the process of assaying gold, the real quantity taken is very small, generally from 6 to 12 grains; and this is termed the *assay pound*. It is subdivided into 24 carats, and each carat into 4 assay grains, and each grain into quarters; so that there are 384 separate reports for gold. When the gold assay pound is only 6 grains, the quarter assay grain only weighs 1-64th of a grain. This will give an idea of the accuracy required in the weights and scales used for such delicate operations.

CARBON in a perfectly pure state is the diamond: less pure forms are plumbago, graphite, coke, anthracite, and charcoal. For its various properties, see these different heads. The soot and smoke of lamps, gas, and other substances of vegetable origin, is carbon almost pure. Carbon has many uses: it forms the base of a durable ink; of crayons; of the filtering substance, such as common charcoal, bone, and ivory black. It is an admirable manure for the soil: it is one of the best substances for reducing metals. When a piece of charcoal, which is very clean, and free from ash, is immersed in a solution of metallic salt, the metal itself is deposited on the charcoal with all its natural brilliancy. Salts of tin, copper, platina, silver, and gold, furnish very beautiful deposits. When the salts are too acid these effects are not produced. The weak salts of copper often yield upon charcoal the most varied shades of color, from the rich azure blue to the deep copper color. There are some parts of charcoal for which some metals exhibit a preference to that of others.

In the three first forms it has a crystalline arrangement. In the others it is amorphous, and generally presents itself as a black, brittle, hard substance, easily powdered, and quite unalterable at common temperatures.

CARBONATES. Salts containing carbonic acid. They are recognized by the effervescence which is excited when they are put into dilute muriatic acid. *Carbonate of lime* is one of the most important of these compounds, forming the varieties of marble, limestone, calcareous spar, chalk, &c. Carbonate of lime consists of

Lime........	1 atom = ..	28..	56
Carbonic acid	1 " = ..	22..	44
	1	50	100

Carbonate of potash and carbonate of soda are also important salts. (*See* Potash, Soda.) *Carbonate of ammonia* is used in medicine; it is a white pungent salt, commonly known under the name of *smelling salt*. *Spirits of hartshorn* is a solution of impure carbonate of ammonia, obtained by distilling bone or horn.

CARBONIC ACID. This important compound is obtained when any form of carbon, such as the diamond or pure charcoal, is burned in oxygen gas. It consists of 6 carbon + 16 oxygen = 22 carbonic acid; or of

Carbon ..	1 atom....	6....	27·27
Oxygen..	2 "	16....	72·73
	1	22	100·00

100 cubical inches of carbonic acid gas weigh 47·3 grains. Under a pressure of 36 atmospheres, at the temperature of 32°, it becomes liquid; and when the pressure which retains it in the liquid state is removed, the rapidity of the evaporation, and the sudden and enormous expansion of the vapor, are such as to produce a degree of cold under which the acid solidifies, forming a white concrete substance possessed of very extraordinary properties. Mr. Faraday was the first who liquefied carbonic acid, but

it was first described as a solid by M. Thilourier.

At common temperatures and pressures water absorbs its own volume of carbonic acid; under a pressure of two atmospheres it dissolves twice its volume, and so on. Carbonic acid imparts briskness and a slightly pungent and sour taste to water thus impregnated with it: it also confers the effervescent quality upon many mineral springs. Carbonic acid is recognised by its rendering lime-water turbid. It extinquishes flame and suffocates animals; hence the miners call it *choke damp*. Carbonic acid is contained in marble, chalk, and all the varieties of lime-stone; from which it is extracted by strong heat, as in the process of *burning* lime; or by the action of stronger acids, in which case the carbonic acid escapes with *effervescence*. Mountains of lime-stone, therefore, are great natural repositories of carbonic acid. This gas is also produced during the respiration of animals, and is evolved in the process of fermentation.

CARBONIC OXIDE. A gas composed of

Carbon	..1 atom....	6.....	42·8
Oxygen	..1 "	8.....	57·2
	4	14	100·0

100 cubical inches weigh 30·2 grains. It is fatal to animals, and extinguishes flame; but it burns in contact with air, and forms carbonic acid. It is obtained by passing carbonic acid over red-hot charcoal, or by heating a mixture of chalk or pounded marble and iron or zinc filings to redness. It is not absorbed by water.

CARBONIFEROUS. A geological term, generally applied to beds or strata containing coal.

CARBOY. A large globular bottle of green glass protected by basket-work. Carboys are seldom used, except for containing certain acids and other highly corrosive liquids likely to act upon stoneware. A carboy of oil of vitriol usually contains about 160 lbs. of that acid, or 12 gallons of water.

CARBUNCLE. The ancient name of a gem, probably corresponding with our precious *garnet*.

CARBURET OF SULPHUR. A limpid volatile liquid of fetid smell and acrid taste. It boils at 112° F., and evaporates so rapidly as to congeal mercury in a vacuum. It is composed of two atoms of sulphur and one of carbon. It is used as a solvent for caoutchouc.

CARBURETTED HYDROGEN. A generic name for the compounds of carbon and hydrogen, of which there are several, viz.: oil and coal gas, oil of lemons, turpentine, naphtha, otto of roses, &c.

CARDS—CARDING MACHINES. Instruments for arranging cotton and other fibres. After picking and disentangling, the cotton is in the form of a very clean, light, downy substance, consisting of short fibres thoroughly disentangled. But these fibres are not *parallel:* they lie across each other at every imaginable angle, and any attempt to combine them together in this state would be fruitless; they must be rendered parallel, and to effect this is the object of the beautiful operation of *carding*, one of those which have exercised such a large amount of inventive ingenuity. If we were to take two combs, and pass the teeth of one between those of the other, we should have a rude idea of the process of carding, especially if we had a few fibres of cotton entangled among the teeth: for the movement of the two combs would tend to arrange the fibres in some degree parallel. A number of pieces of wire are inserted in a piece of wood or leather, so that all shall project to an equal distance and at an equal angle; and if two such pieces of apparatus were placed with their wires in contact, and moved in contrary directions, a few fibres of cotton placed on the lower one would be *combed out* by the upper one, and arranged parallel. In various stages of the history of the manufacture, the two cards have been arranged in different ways. Sometimes one was on a convex surface, and the other on a concave surface fitted to it; sometimes one was on a cylinder, and the other on a flat surface; sometimes both were on the surfaces of cylinders. But the principle of action is the same in all, and is nothing more or less than a process of combing. In some arrangements the cotton is brought into the form of a "lap," or flat layer, by the scutching-machine, and in that state transferred to the carding-engine; while in other cases the latter is fed by hand with cotton.

These card-combs are sometimes set on cylinders, and applied to the burring and carding of cotton and wool.

In 1848, letters patent were granted for the mode of constructing the hollow cylinder, to which the teeth of burring or carding cylinders are to be attached. A light cylinder of tinned sheet metal is first made,—wire, covered with tin, is then wound tight and spirally all over the convex surface of the cylinder. Metal proper for soldering is then poured over the surface thus formed, which renders the whole firm and compact, the surface is then turned true, and the cylinder is ready to receive the teeth of such character as may be desired.

In the same year patents were granted for a new method of constructing burring cylinders. A proper cylinder is first constructed for the reception of the teeth, wire of proper size is then rolled flat, and afterwards planed in such a manner as to leave a rib or shoulder its whole length on the one side, and a thin edge on the other. Notches are then filed into the thin edge at intervals, thus forming teeth. The convex surface of the cylinder is then grooved at proper intervals around its surface, and the toothed strips on the edge having the shoulder, are laid into the groove, and the ridges of metal between the grooves are forced down upon the shoulders to hold them in place; or the toothed strips are wound upon the cylinder and soldered, and the cylinder is finished, the shoulders, &c., giving proper distance between the rows of teeth.

A patent was also granted for a carding machine, in which a cylinder, like Parkhurst's burring cylinder, is made to work against the main cylinder. When cards are used the teeth will yield, and a knot, closely matted together, might be carried through the machine without being properly opened; but the cylinder above-mentioned would hold such a knot, and bring it successively in contact with the teeth of the main cylinder, until by degrees it would be opened and carried forward.

Another patent has been granted for improvements in this variety of machines, which consists principally in banding from the main cylinder, and thus giving a high speed to the workers with little increase of power.

Messrs. J. Lambert and J. Zimmerman, of Waterloo, New York, have made an improvement in the working of carding machines, for which they have taken measures for a patent, and which is said to card double the quantity at least, in the same time, that has usually been done by the old mode of operation. The "workers," instead of carrying round the wool from the main cylinder, at once, by revolving in a contrary direction, revolve with it, and carry the wool but a short distance to the strippers, and thus, by the way, they are geared; the "workers" are rendered workers indeed, and not merely in name.

CARMINE. A brilliant lake, made of the coloring matter of the cochineal insect, combined with alumina and oxide of tin. It is of different shades,—either dependent on the amount of alumina present, or of the adulterations to which it is liable. Vermillion is a common one of these. It is always easy to discover the amount of impurity, as true carmine dissolves in water of ammonia, and leaves the adulteration behind. Starch is a common impurity. To make ordinary carmine, take 1 lb. powdered cochineal, 8½ drachms of carbonate of potash, 1 oz. of alum, and 8½ drachms of fish glue; boil the cochineal and potash together in thirty quarts of water in a copper, take it off the fire, and let it settle, then add the alum in powder: after fifteen minutes the liquor clears, and may be decanted from the sediment,—the bright clear fluid containing the carmine. This is next decanted into another copper, the glue dissolved in a large quantity of water added, and the whole boiled; the carmine separates from the liquid, and rises like a scum to the top; this must be collected, and drained on a filter of canvas or linen.

The *China* carmine is made by adding to the solution of cochineal and alum, when freed from sediment, a solution of tin (chloride), until the carmine ceases to be thrown down. Ordinary carmine may be brightened by dissolving in water of ammonia, and precipitating by acetic acid, washing in alcohol, and drying. Carmine, dissolved in ammonia, is used by painters, and called liquid carmine. Carmine is used in miniature painting, fine inks, water colors, and artificial flower tinting, because it is more transparent than the other colors.

CARPET. An ornamental covering for the floor. The manufacture of carpets is carried on to great perfection in this country. The principal varieties are the Brussels, Axminster, Wilton, Kidderminster, and Venetian. They are generally composed of linen and worsted. In some the pile is cut so as to give the carpet the character of velvet, as in the Wilton carpets. Kidderminster or Scotch carpets are entirely fabricated of wool.

The manufacture may be classed under two heads: that of double fabrics, and that cut to imitate velvets. The Jacquard loom has lately been used in carpet manufacture.

Plain Venetian carpets for stairs and

passages, are woven in simple looms, provided with common heddles and reed. The warp should be a substance of worsted yarn so as to cover in the weft. Kidderminsters are composed of two woollen webs which intersect each other, so as to produce definite figures. Brussels carpeting has a basis composed of a warp and woof of strong linen thread. In the warp there is added to every two threads of linen ten threads of woollen, of different colors. The use of the linen thread is to bind the worsted together, and is not visible on the upper surface. The worsted yarn, which is raised to form the pile, is not cut; in the Wilton it is cut. The following figure and description will explain the construction of the three-ply imperial Scotch and two-ply Kidderminster carpet-loom, which is merely a modification of the Jacquard *métier*. The Brussels carpet-loom, on the contrary, is a draw-boy loom on the damask plan, and requires the weaver to have an assistant.

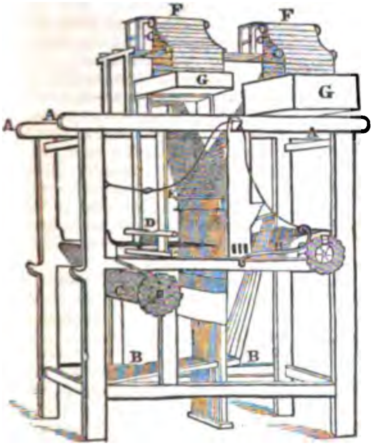


Fig. A A A, is the frame of the loom, consisting of four upright posts, with caps and cross-rails to bind them together. The posts are about six feet high. C C, the cloth-beam, is a wooden cylinder, six inches or thereby in diameter, of sufficient length to traverse the loom, with iron gudgeons in the two ends, which work in bushes in the side frame. On one end of this beam is a ratchet-wheel, with a tooth to keep it from turning round backwards by the tension of the web. D, the lay, with its reed, its under and upper shell, its two lateral rulers or swords, and rocking-tree above. There are grooves in the upper and under shell, in to which the reed is fitted. E, the heddles, or harness, with a double neck attached to each of the tower or card mechanisms F F, of the Jacquard loom. The heddles are connected and work with the treddles B B, by means of cords, as shown in the figure. G G are wooden boxes for the cards. H, the yarn or warp-beam.

Mr. James Templeton, of Glasgow, Scotland, has taken out a patent in England for an improved method of manufacturing carpets, the designs of which are produced from the *weft* threads, which are previously printed to produce the design or pattern. He makes velvet carpets by employing *chenile* weft, previously printed, which weaves up into the patterns designed; he also makes carpets by the printed weft, which work up into patterns on both sides of the carpet, like those of the ingrain carpet. The principle of this important improvement in carpet-weaving to do away with the *Jacquard*, lies in the mode of printing and preparing the weft previous to weaving.

The most extensive manufacturers in the United States are at Thompsonville. They use 10,000,000 lbs. of wool, and 10,000 lbs. of flax-yarn per annum. They manufacture three-ply Brussels and Axminster carpeting of the richest patterns, the weaving being mostly done at present on hand-looms. They have, however, introduced power-looms into this factory, for weaving rugs and Axminster carpets. The wool for Axminster carpeting is first woven in a web, and afterwards cut in strips, forming what is called chenile card; this is done on a machine, invented by Messrs. Davidson and Parks, of Springfield, Vt., which is the first and only one of the kind, and has more than paid for itself in six months. This machine has over 200 hundred cutters, or knives, which are attached to a cylinder, making some 800 revolutions, and cutting full two yards of the web per minute into strips, which being passed over a grooved cylinder, heated by having hot irons inserted within it, it is prepared for weaving. Besides the large carpet establishment, there is in the same village a factory, 150 feet by 143 on the group, and five stories high, for the manufacture of knit shirts, drawers, and fancy ginghams. This establishment has 30 sets of wool cards, and 25 or 30 gingham rooms.

CARTHAMUS. (*See* SAFFLOWER.)

CASE. Is the receptacle for the types, from which the compositor gathers them separately, and arranges them in lines and pages to print from. They are always in pairs; one of which is styled the upper case, and is divided into ninety-eight boxes or recesses of equal size, in which are deposited the capitals, small capitals, accented letters, figures, &c.; the other is styled the lower case, and is divided into fifty-four boxes or recesses, of unequal size, containing the small letters, spaces, &c., the letters most in use having the largest boxes assigned to them. The cases are two feet nine inches long, one foot four inches and a half broad, and a full inch deep.

CASE HARDENING. A process by which tools and other iron articles have their surfaces converted into steel. This is sometimes effected by putting the articles into an iron box filled with charcoal, and cemented together for some time; by this means, a thin coating of steel is formed on the outside. Immersion of the articles in boiling water or boiling oil partially steels the surface. Ferrocyanide of potassium is used in powder for this purpose, thus:—the article when polished is made red hot, then rubbed with the powdered salt. It is decomposed by the heat, and the iron is then quenched in cold water. Gas flame hardens iron very well.

CASHMERE SHAWLS. First imported from that province, now imitated in France to great perfection. They are made from the downy wool found about the roots of the hair of the Thibet goat. The oriental cashmeres are woven by slow processes, and bring from 500 to 2000 dollars each, on sale, but with the draw loom and the jacquard loom the French shawls rival the oriental, and some of them have the advantage of being woven without seam in a single piece.

CASSAVA, or *Tapioca*, is obtained principally from the *Jatropha Manioc*. Its extraction is remarkable for the large quantity of hydrocyanic acid which the juice of that plant contains. When distilled, it affords, as a first product, a liquor which, in the dose of 30 drops, will cause the death of a man in the course of six minutes; and it is well known that this acid does not pre-exist in the plant, but that it is generated in it, after it is grated down into a pulp. It would be interesting to discover in what state the substance exists, from which it proceeds. After the grating of the root, and washing of the pulp, this is dried upon hot plates, to agglutinate it into the form of concretions, constituting the tapioca of commerce. But the starch of the washed root floated in water, is spontaneously deposited, and, when dried in the sun, forms *Cassava* flour, called *moussache* by the French.

CASSIUS, PURPLE OF. So called from its inventor. A beautiful purple used in porcelain painting, and for staining glass. It is formed by immersing tin in a solution of gold. It is probably a mixture of oxide of tin and finely divided gold.

CASTING—of Guns. A new method has been resorted to at the Cannon Foundry, near Pittsburgh, for the production of guns. Instead of bringing them from the mould solid, and afterwards boring them, they are cast with the proper bore, the core being carefully prepared so as to enclose a circle of cold water, which it receives and discharges in a continuous current, during the process of cooling, the object, probably, being to chill the inner surface more rapidly than the outer, and thereby give it a greater density and strength. The plan is the suggestion of Lieut. Rodman: and two guns—one cast on the old and the other on the new plan—having been subjected to the usual tests, the first exploded on the 84th, and the latter on the 255th round. This shows a great superiority over the common mode of making cannon, and if future experiments substantiate this successful one, Lieut. Rodman's invention will come into general use.

CASTING—in Metal. (*See* FOUNDRY.)

CATECHU. The extract of the Acacia Catechu, an astringent substance, consisting of tannin and extractive matter imported from Bengal and Bombay. The tannin constitutes one-half of the extract, and unlike that from galls, is soluble in alcohol, and more soluble in water. It is much used for brown color in dyeing and calico-printing.

CATGUT. The strings of musical instruments, clock cords, and a few other materials of support, are made of an animal substance called catgut, which is the twisted muscular coat of the intestines of cattle and sheep. To separate the muscular from the peritoneal and mucous coats, the intestine is steeped, scoured, fermented, and inflated. It is then twisted, rubbed smooth with horsehair, bleached with sulphur, and dried. The

Italian catgut for violin and harp-strings is the finest. Lean animals furnish the best catgut; hence this manufacture might in our Western States be made not only profitable, but of superior quality.

CAUSTIC, Lunar, is the salt obtained by evaporating gently the nitric acid solution of silver to dryness, in a silver vessel, continuing the heat until it melts; and when in fusion, pouring it into moulds, or cast it into sticks, the size of the barrel of a common quill.

CAVIAR. The salted row of the sturgeon: a manufacture confined to the Russians.

CAULKING SHIP consists in driving a quantity of oakum or old ropes untwisted, and drawn asunder into the seams of the planks, or in the intervals, where the planks are joined together in the ships, deck, or sides, in order to prevent the entrance of water. After the oakum is driven into these seams, it is covered with hot melted pitch or resin to keep the water from rotting it. Among the Poles in Europe a sort of unctuous clay is used for the same purpose on their navigable rivers.

CEDRA. The fruit of a species of citron, having a thick peel, and an epidermis having a fragrant and essential oil. The peel is used in making liqueur.

CELESTINE. Native sulphate of strontia; decomposed by ignition with charcoal into sulphuret of strontia, which is converted into nitrate by saturation with nitric acid, evaporation, and crystallization. The nitrate is used for red light in theatres.

CEMENTATION implies the imbedding of any solid substance in a pulverulent matter, and exposing both to ignition in an earthen or metallic case. Iron is thus cemented with charcoal to form steel, and bottle-glass with gypsum powder, or sand, to form Reaumur's porcelain.

CEMENTS. Substances capable of taking the liquid form, and of being in that state applied between the surfaces of two bodies, so as to unite them by solidifying. They may be divided into two classes, those which are applied through the agency of a liquid menstruum, such as water, alcohol, or oil, and those which are applied by fusion with heat.

The *diamond* cement for uniting broken pieces of china, glass, &c., which is sold as a secret at an absurdly dear price, is composed of isinglass soaked in water till it becomes soft, and then dissolved in proof spirit, to which a little gum resin, ammoniac, or galbanum, and resin mastic are added, each previously dissolved in a minimum of alcohol. When to be applied, it must be gently heated to liquefy it; and it should be kept for use in a well-corked vial. A glass stopper would be apt to fix so as not to be removable. This is the cement employed by the Armenian jewellers in Turkey for glueing the ornamental stones to trinkets of various kinds. When well made it resists moisture.

Shellac dissolved in alcohol, or in a solution of borax, forms a pretty good cement. White of egg alone, or mixed with finely sifted quicklime, will answer for uniting objects which are not exposed to moisture. The latter combination is very strong, and is much employed for joining pieces of spar and marble ornaments. A similar composition is used by copper-smiths to secure the edges and rivets of boilers; only bullock's blood is the albuminous matter used instead of white of egg. Another cement in which an analogous substance, the curd or caseum of milk is employed, is made by boiling slices of skim-milk cheeses into a gluey consistence in a great quantity of water, and then incorporating it with quicklime on a slab with a muller, or in a marble mortar. When this compound is applied warm to broken edges of stoneware, it unites them very firmly after it is cold.

A cement which gradually indurates to a stony consistence may be made by mixing 20 parts of clean river sand, two of litharge, and one of quicklime, into a thin putty with linseed oil. The quicklime may be replaced with litharge. When this cement is applied to mend broken pieces of stone, as steps of stairs, it acquires after some time a stony hardness. A similar composition has been applied to coat over brick walls, under the name of mastic.

The iron-rust cement is made of from 50 to 100 parts of iron borings, pounded and sifted, mixed with one part of sal-ammoniac; and when it is to be applied, moistened with as much water as will give it a pasty consistency. Formerly flowers of sulphur were used, and much more sal-ammoniac in making this cement, but with decided disadvantage, as the union is effected by the oxydizement, consequent expansion, and solidification of the iron powder, and any heterogeneous matter obstructs the effect. The best proportion of sal-ammoniac is, I believe, one per cent of the iron borings. Another composition of the same kind is made by mixing 4 parts of fine borings, or filings of iron, 2 parts of potter's clay, and 1 part of pounded potsherds, and making them into a paste with salt and water. When this cement is allowed to concrete slowly on iron joints, it becomes very hard.

For making architectural ornaments in relief, a moulding composition is formed of chalk, glue, and paper paste. Even statues have been made with it, the paper aiding the cohesion of the mass.

Mastics of a resinous or bituminous nature which must be softened or fused by heat are the following:

Mr. S. Varley's consists of sixteen parts of whiting sifted and thoroughly dried by a red heat, adding when cold a melted mixture of 16 parts of black resin and 1 of bees'-wax, and stirring well during the cooling.

Mr. Singer's electrical and chemical apparatus cement consists of 5 lbs. of resin, 1 of bees'-wax, 1 of red ochre, and two table-spoonsful of Paris plaster, all melted together. A cheaper one for cementing voltaic plates into wooden troughs is made with 6 lbs. of resin, 1 pound of red ochre, ½ of a pound of plaster of Paris, and ¼ of a pound of linseed oil. The ochre and the plaster of Paris should be calcined beforehand, and added to the other ingredients in their melted state. The thinner the stratum of cement that is interposed, the stronger, generally speaking, is the junction.

Boiled linseed oil and red lead mixed gether into a putty are often used by coppersmiths and engineers, to secure joints. The washers of leather or cloth are smeared with this mixture in a pasty state.

The resin mastic alone is sometimes to-used by jewellers to cement by heat cameos of white enamel or colored glass to a real stone, as a ground to produce the appearance of an onyx. Mastic is likewise used to cement false backs or doublets to stones, to alter their hue.

Melted brimstone, either alone, or mixed with resin and brick dust, forms a tolerably good and very cheap cement.

Plumber's cement consists of black resin one part, brick dust two parts, well incorporated by a melting heat.

The bituminous or black cement for bottle corks, is pitch hardened by resin and brick dust. The following makes a good cement for mastic works: mix 50 parts of silicious sand, 50 parts of lime marl, or pulverized brown sand stone and 8 parts of litharge. When the cement is used it is to be ground up with linseed oil.

An excellent cement for resisting moisture is made by incorporating thoroughly 8 parts of melted glue, of the consistence used by carpenters, with 4 parts of linseed oil, boiled into varnish with litharge. This cement hardens in about forty-eight hours, and renders the joints of wooden cisterns and casks air and water tight. A compound of glue with one-fourth its weight of Venice turpentine, made as above, serves to cement glass, metal, and wood, to one another. Fresh made cheese-curd, and old skim-milk cheese, boiled in water to a slimy consistence, dissolved in a solution of bicarbonate of potash, are said to form a good cement for glass and porcelain. The gluten of wheat, well prepared, is also a good cement. White of eggs, with flour and water well mixed, and smeared over linen cloth, forms a ready lute for steam joints in small apparatus.

White lead ground upon a slab with linseed oil varnish, and kept out of contact of air, affords a cement capable of repairing fractured bodies of all kinds. It requires a few weeks to harden. When stone and iron are to be cemented together, a compound of equal parts of sulphur with pitch answers very well.

For hydraulic cement, *see* MORTAR.

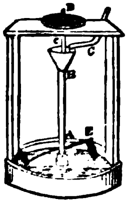
Mr. Keating, of London, has patented a mode of combining gypsum or other calcareous substances with borax, for a cement.

Separate solutions of borax and crude tartar are made, and then mixed: calcined gypsum is then added in lumps to the liquor, and allowed to remain till it has absorbed all it will take up. It is then taken out and heated in an oven: again put in the solution and afterwards burned: when it is fit for use.

CENTIGRADE DIVISION. The division into *grades* or degrees by hundredth parts. A unity of any denomination being divided into 100 equal parts, forms a centigrade scale; but the term most frequently occurs in scientific works, in reference to the French division of the scale of the thermometer. The fixed points of the thermometric scale are the points at which water freezes on the one hand, and boils on the other; the distance between these two points being divided into 100 degrees, the centigrade scale is formed. In Fahrenheit's scale, which is usually applied to the thermometer in this country, the same distance is divided into 180 degrees; a degree of the centigrade scale is therefore greater than a degree of Fahrenheit in the proportion of 180 to 100, or of 9 to 5. Any number of degrees, therefore, on the centigrade scale, being multiplied by 9 and divided by 5, will give the equivalent number of degrees of Fahrenheit. But in comparing temperatures expressed by the two scales, it is necessary to recollect that the zero of Fahrenheit's scale is not placed at the freezing point, but 32° below it. An example will best show how this is to be taken into account. Let it be required to express on Fahrenheit's scale the temperatnre corresponding to 10° centigrade. Here $10 \times 9 \div 5 = 18$; to this add 32, and we have $18 + 32 = 50$; so that 10 degrees of the centigrade scale correspond to 50 degrees of Fahrenheit's.

CENTRIFUGAL FORCE. The force by which a body in rotation tends to recede from the centre of motion: CENTRIPETAL FORCE, that by which a body in motion is urged towards a centre, and compelled to describe a curve instead of a straight line.

CENTRIFUGAL MACHINE. A machine moved by the centrifugal force of water; frequently called from its inventor, *Barker's Mill.* It consists of a hollow metal cylinder or pipe of metal placed upright, and resting on a pointed steel pivot at A. The pipe is widened or extended into a funnel shape at the top B, and is kept in its position by a vertical steel axis C D, passing through a frame at the top. Towards the lower extremity, two or more small pipes A E, A F, with closed external ends, are inserted at right angles to the axis. In the side of each of these an orifice is made as near as possible to the end, and on opposite sides, so that water from them may spout horizontally in opposite directions. Water is conveyed into the funnel at the top, through the pipe G, in such quantities that the tube is kept constantly full, while the discharge is going on at the orifice near the extremities of the horizontal pipes. In this state of things the resistance or reaction generated by the water issuing from the side-holes is such as to throw the vertical pipe, with its arms and axis, into rapid rotatory motion; and this axis may communicate its motion or power to wheelwork or machinery, or to a mill-stone connected with its upper end. A machine of the same construction, but having the arms at the upper end, and turned rapidly by means of a wheel and pinion, was invented by a Mr. Erskine for raising water. Centrifugal Machine is also used synonymously with *Whirling Machine.*



CERASIN. Cherry-tree gum: a name given to gums which swell and soften, but do not readily dissolve in water.

CERATE. An ointment made of wax and oil, or spermaceti.

CERATRIN. The bitter principle of Iceland moss.

CEREAL GRASSES. Those which give flour fit for bread: such as corn, wheat, rye, barley, oats, rice, and millet.

CERINE. One of the principles of wax: soluble in alcohol; there is nearly 80 per cent. of it in bees-wax. It is white, melts at 134°, and is carbonized by sulphuric acid. Cork grated and boiled in alcohol, furnishes a substance resembling cerine.

CERITE. A siliceous oxyde of cerium.

CERIUM. A metal named after the planet Ceres, and discovered in 1803 by Hisinger and Berzelius in a Swedish mineral termed *cerite*, and since found by Dr. Thompson in *Allanite*, a mineral from Greenland. It is said to be a white brittle metal, very difficult of fusion, and volatile when intensely heated; but we are scarcely acquainted with it in its metallic state. Its equivalent number appears to be 48, on the hydrogen scale.

CEROSTROTUM, or CESTROTUM. A species of encaustic painting, executed chiefly on horn or ivory with a particular sort of stylum called a cestrum, which was pointed at one end and flat on the other. The cestrum was heated, and with it the lines of the subject were burnt in, and wax introduced into the furrows made by the heated instrument. Doors were sometimes ornamented with this species of painting.

CERULIN. Indigo dissolved in sulphuric acid.

CERUSE. Carbonate of lead.

CETINE. Pure spermaceti.

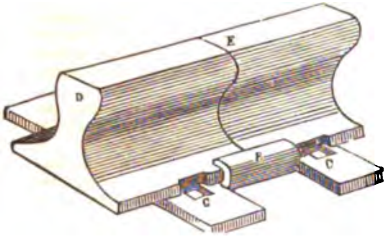
CHABAZITE. A variety of Zeolite.

CHAFF. The husk or withered calyx of grasses, and more especially of the bread corns. The term is also applied to straw or hay cut into very short lengths, and used for mixing with corn, roots, or other food for horses or cattle. This kind of chaff, in greater lengths, is also used for mixing with mortar on some parts of the Continent, more particularly in Germany and Russia; and it is used as a substitute for hair in making plaster for rooms. Both stubble and cut hay were used by the ancient Egyptians in making bricks.

CHAINWORK. A peculiar style of fabric to which hosiery and tambouring belong.

CHAIR-RAIL. Mr. Van Anden has secured a patent for a wrought iron chair, which displays much ingenuity, and is an useful invention. Figure, No. 1, is a view of the rail secured in the chair, and figure, No. 2, is a view of the chair itself.

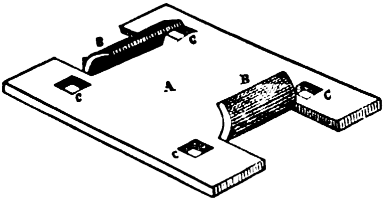
Fig. 1.



D E are the sections of two rails placed together and secured at the joint on the chair by the jaws, B B. The chair is bolted down by the spikes, C C. In fig. 2 the chair is represented as made of a single block or plate, A, of wrought iron.

The machine takes the bar of iron as it comes from the rolls—cuts it—forms the jaws, punches the holes, and completes the chair at a single blow. The chair is set in its proper place on the track, spiked down, and the ends of the two rails brought together within the jaws, as represented in fig. 1. The jaws are then hammered down snug upon the bed plate of the rails, thus securing them in the most perfect manner. The advantages of the wrought over the cast iron rail chair admits of but little argument.

Fig. 2.



CHALCEDONY. A semi-transparent silicious mineral, apparently formed by the infiltration of silicious matters originally in a state of solution. It is of various colors, and often banded. The finest specimens are said to have been found at Chalcedon in Asia.

CHALCOGRAPHY. The art of engraving on brass and copper.

CHALK. Earthy carbonate of lime. (*See* LIME.)

CHALYBEATE. Medicines and mineral waters containing iron are called chalybeates.

CHAMELEON MINERAL. A compound of manganesic acid and potash, which presents a variety of tints when dissolved in water. As it has of late been largely employed for whitening tallow, palm oil, and decoloring other organic matters, it merits description. It exists in two states; one of which is called by chemists the manganate of potash, and the other the oxymanganate; denoting that the first is a compound of manganic acid with potash, and that the second is a compound of oxymanganic acid with the same base. They are both prepared in nearly the same way; the former by calcining together, at a red heat in a covered crucible, a mixture of one part of the black peroxide of manganese with three parts of the hydrate of potash (the fused potash of the apothecary). The mass is of a green color when cold. It is to be dissolved in cold water, and the solution allowed to settle, and become clear, but by no means filtered for fear of the decomposition to which it is very prone. When the decanted liquid is evaporated under the exhausted receiver of an air pump, over a surface of sulphuric acid, it affords crystals of a beautiful green color, which should be laid on a clean porous brick to drain and dry. They may be preserved in dry air, but should be kept in a well-corked bottle. They are decomposed by water, but dissolve in weak water of potash. On diluting this much, decomposition of the salt ensues, with all the chameleon changes of tint; red, blue, and violet. Sometimes a green solution of this salt becomes red on being heated, and preserves this color even when cold, but resumes its green hue the moment it is shaken. The original calcined mass, in being dissolved, always deposits a considerable quantity of a brown powder, which is a compound of the acid and peroxide of manganese combined with water. Much of the potash remains unchanged, which may be recovered.

A permanent oxymanganic salt may be made as follows:—Melt chlorate of potash over a spirit lamp, and throw into it a few pieces of hydrate of potash, which immediately dissolve, and form a limpid liquid. When peroxide of manganese in fine powder is gradually introduced into that melted mixture, it immediately dissolves, with the production of a rich green color. After adding the manganese in excess, the whole is to be exposed to a gentle red heat, in order to decompose the residuary chlorate of potash. It is now a mixture of manganate of potash, chloride of potassium and peroxide of manganese. It forms with water a deep green-colored solution, which when boiled assumes a fine red color, in consequence of its becoming an oxymanganate, and it ought to be decanted off the sediment while hot. By cooling, and still more after further evaporation, the oxymanganate of potash separates in crystals possessed of great lustre; but toward the end colorless crystals of chloride of potassium.

CHARCOAL. A form of carbon, obtained by burning wood with the imperfect access of air, or by heating or distilling it in iron cylinders so constructed as to allow of the collection of the volatile products; among which are *tar*, and *pyroligneous acid*, which is impure vinegar. Charcoal, exclusive of its important use as a fuel, is possessed of some curious and valuable properties. It is a very bad conductor of heat; and hence powdered charcoal is used to surround tubes and vessels which are required to retain their heat. It is not injured by air and moisture; hence stakes and piles are superficially charred to preserve them. It is infusible; and provided air be carefully excluded, it undergoes no change in most intense heats. It absorbs air and moisture, and also the coloring and odoriferous parts of many animal and vegetable substances. Tainted flesh and putrid water are thus sweetened by the action of powdered charcoal, especially by what is called *animal charcoal*, obtained by burning bone, or the clippings of hides, leather, &c. Colored vegetable solutions filtered through well burned charcoal are materially decolored by it: when burned in oxygen or air, it is converted into *carbonic acid*. (*See* DIAMOND and CARBON.) Common charcoal, intended merely for fuel, is prepared by cutting pieces of wood from 1 inch to 8 inches in diameter, into lengths of from 1 foot to 8 feet, forming them into a conical pile, and covering them with turf or clay; leaving two or three small holes, close to the ground, for lighting the wood, and boring through the turf in the upper part of the cone a few other small holes for the escape of the smoke. The pile being lighted at the several holes along the bottom, continues burning with a slow smouldering flame for a week or two, and is allowed to cool before the turf is removed. In the case of very high winds, the holes to the windward are stopped, to prevent combustion from going on with too great rapidity. Charcoal obtained by distilling beech-wood, log-wood, willow, and other woods which are free from resin, is called *cylinder charcoal*. The charcoal employed in the manufacture of gunpowder is now always so prepared.

It is not, however, by any means as good as that prepared by the burning of peat or turf. More charcoal is obtained by the slow combustion of the wood than by the quick. The quantity of charcoal obtainable from wood varies from 12 to 25 per cent.

Animal charcoal is superior in its decolorizing power to vegetable charcoal. In filtering ale through it, it was found to abstract all the bitter principle; it has also the property of separating sulphate of quina, many salts of the alkaloids, as well as other saline matters from their solutions.

Its absorbing power over gases is greatest when it is fresh. It acts with different energy on different gases; thus, one cubic inch of charcoal will absorb of

Ammoniacal Gas	90	cubic inches.
Muriatic Acid	85	"
Sulphurous Acid	65	"
Sulphuretted Hydrogen	55	"
Carbonic Acid	35	"
Oyxgen	9¼	"
Hydrogen	1¾	"

Hence the great value of charcoal thrown into cesspools and privies, to absorb odors; hence its use, added to guana, fœcal matter, urine, or any substance giving off gases valuable for growth of vegetation. Its chief value as a manure depends on this property. Charcoal is occasionally used as a polishing powder.

CHARRED WOOD. Wood, the outer

surface of which has been carbonized by burning, in order to preserve it from decay when it is buried in the soil.

CHARRING OF POSTS. The practice of carbonizing by burning that portion of the surface of wooden posts which is to be inserted in the ground. The object is to prevent the posts from decaying, more especially at the surface of the ground, or, as the common phrase is, between wind and water. The practice is common in most parts of Europe, and even in Russia and Sweden, though timber is there so abundant. Dipping the ends of the timber in oil of vitriol, diluted with four parts of water, chars the outside of the wood, and answers very well for stakes and fence wood.

CHASING. Embossing in metal. The work to be embossed as bassi relievi are punched out from the back, and then cut on steel blocks or puncheons, and cleared with small chisels or gravers.

CHEESE consists of the curd of milk mixed with some of the fatty matter and sugar of milk. Difference in the quality of the milk and the dairy management determines endless variety in the produce. To separate the curd or casein it is necessary to acidify the milk, and adopt such other means as will separate the curd rapidly and effectually. The liquid portions have then to be expressed from the cake of curd. Any acid will coagulate milk, but rennet is the acidulous substance always used. Before adding rennet new milk should be heated up to 95° F.; skim milk not so high. This separates the curd in a tougher and harder state. The milk should not be *fire fanged* in the heating. A naked fire is objectionable; immersing the milk vessel in a larger one containing boiling water is the proper mode. Vessels with a double bottom might be used for this purpose. The rennet ought never to be putrid, nor added in too large quantity, for then the curd is too tough. If too little, time is lost. When acids, as vinegar, are used instead of rennet, the cheese is apt to have their flavor.

The acid, formed by the addition of the rennet, should be separated slowly from the whey, for if done hastily, the fat of the milk is squeezed out, and the cheese is poorer. The whey should, however, be completely removed, for as it contains sugar and lactic acid, if left behind, fermentation will set in. Curd-mills and cheese-presses are used to effect this removal.

The preservation of the fresh cake depends on the purity of the salt, and the mode of applying it.

Cheese is then colored sometimes by saffron, but chiefly by annotto, in the proportion of ½ an oz. to 60 lbs. of cheese; sometimes the marigold and carrot are boiled in milk, and used as coloring.

In milk of average quality, there is from 4 to 5 per cent. of pure casein, which, if all extracted, would give, according to Professor Johnston, 6 to 7 lbs. of skim milk cheese, or 9 to 10 lbs. pure new milk cheese, in every 100 lbs. of milk; and on an average, 8 to 10 lbs. of good milk in summer, will yield 1 lb. of whole milk cheese. The following abstract of European cheeses, taken from *Brande's Encyclopedia*, may be interesting:

"The following are the principal British cheeses: *Brickbat*, formed of new milk and cream, chiefly in Wiltshire, in the autumn, and sold in little square pieces about the size of brickbats. *Cheddar*, round thick cheeses, weighing about 150 or 200 lbs., with a spongy appearance, and the eyes or vesicles filled with a rich oil. *Cheshire*, large round thick cheeses, commonly weighing from 100 to 200 lbs. each, —solid, homogeneous, and dry and friable rather than viscid. They are made from the whole of the milk and cream, the morning's milk being mixed with that of the preceding evening previously warmed. *Derbyshire* is a small white rich cheese. *Dunlop*, originally made in Ayrshire, but now general throughout Scotland, is large, round, white, buttery, and weighs from 30 to 60 lbs. This and the Derbyshire cheese are very much alike in form, color, and flavor. *Gloucester*, large, round, and mild; buttery rather than friable. There are two kinds, the single and double Gloucester: the single is made of the milk deprived of about half the cream, and the double of the milk with the whole of the cream. *Green* or *Sage* cheese may be made of any of the other kinds, by mixing the milk before it has curdled with a decoction of sage leaves, among which some put a few flowers of marigold and leaves of parsley. In the Highlands of Scotland the leaves or seeds of lovage are added to the sage, which communicate a very strong flavor. *Lincolnshire* is made of new milk and cream; it is quite soft, not above 2 inches thick, and will not keep more than two or three months. *Norfolk*, the weight is generally from 30 to 50 pounds; the curd is dyed yellow with arnotto or saffron, and though not a rich cheese, it is considered a good keeper. *Soft* or *Slipcoat* is a small, soft, rich cheese, which might almost be mistaken for butter, if it were not white, and which must be eaten in a week or two after making. *Stilton*, so named from the town in Huntingdonshire where it was first brought into notice, but which is made principally in Leicestershire. It is solid, rich, buttery, and white, and, unlike all the other cheeses which have been mentioned, it is twice as high as it is broad. It is much improved by keeping, and is seldom used before it is two years old. It is the dearest of all English cheeses, the price being generally to that of Chester as 2 to 1, or 2 to 1½. In order to induce premature decay and the consequent appearance of age in these cheeses, it is said the makers sometimes bury them in masses of fermenting straw. *Cottenham*, so named from a town in Cambridgeshire; it differs chiefly from the cream cheese of Stilton in being flat, broader, and superiorly flavored. The flavor is said to be owing to the rich grasses which grow on the fens. *Suffolk*, or *skim-milk*, is round and thin, weighing from 25 to 30 lbs. each, and is the best keeping cheese made in England. *Wiltshire* resembles the Cheshire, but is poorer, and of inferior flavor. It is apt to become scurfy, to prevent which it is generally coated over with red paint. *Yorkshire*, or *cream cheese*, is the same as the slip coat cheese, already mentioned.

EUROPEAN CHEESES.—The most remarkable of these are the following: *Parmesan* is chiefly made at Parma and other places in Lombardy, of the curd of skimmed milk hardened by heat. Its flavor is said to be owing to the rich pastures of that part of Italy, where all plants, from the greater quantity of bright sunshine than in Britain, have doubtless their aromatic properties greatly increased. *Swiss cheese* is of various kinds; but the chief sorts are the Gruyere or Jura cheese, and Schabzieger or green cheese: the last is flavored with the seeds and leaves of the melilot (*Melilotus officinalis*). *German cheeses* are of different kinds; but none are celebrated, unless we except that of Westphalia, which is made up into round balls or short cylinders, under a pound weight each. The peculiar flavor which this cheese acquires, arises from the curd being allowed to become putrid before it is compressed. In Holland very good cheese is made, particularly the Edam and Gouda cheeses: the former is very salt, and keeps well at sea. In many parts of the Continent, and even in the interior of Poland and Russia, there are imitations of English cheese made; but what may be called the indigenous cheese of the Russian empire is nothing more than salted curd put into a bag and powerfully pressed, and taken to market as soon as it is made, in the same manner as butter is. In some places, instead of a press, the whey is forced out of the curd by putting it into a long cloth midway between the two ends, while a person at each end twists the cloth in an opposite direction, and thus wrings out the whey. In some miserable Russian villages the curd is exposed for sale in small lumps, retaining the marks of the fingers, which shows that no other pressure has been employed than what can be given with the hand. In France the Roquefort cheese is the most esteemed, and next that of Neufchatel. The former somewhat resembles Stilton, but is much inferior, and the latter is a cream cheese, seldom exceeding a quarter of a pound in weight.

The cheese manufacture is a large and important one in the Northern and Western States, and the exportation is great and increasing. New York is the chief station for export, and the quantity which reaches that city may be estimated from the following abstract from the Patent-Office Report for 1847.

The *Albany Journal* gives the following statement of the amount of Cheese received at Albany and Troy during the past twelve years:

1836,	pounds,	14,060,000
1837,	"	15,500,000
1838,	"	18,810,000
1839,	"	14,530,000
1840,	"	18,820,000
1841,	"	14,170,000
1842,	"	19,004,000
1843,	"	24,831,000
1844,	"	26,677,500
1845,	"	27,542,861
1846,	"	35,560,180
1847,	"	40,314,000

This last having a value of $2,860,354.

The importation of cheese into Great Britain is larger than that of butter. The total quantity in 1846 from Europe amounted to 249,664 cwt., and from the United States to 91,901 cwt. The *American cheese*, however, is said to have some *faults* which need to be corrected to render it acceptable to the English market. These are stated by Mr. Coleman to be, first, the softness of the rind, which renders them liable to crack, and which is imputed to their richness, and the remedy for which is to let the cheese, when taken from the press, remain in brine so strong that it will take up no more salt, for four or five hours. It must not, however, be kept too long in the brine, as it may receive injury. The second fault complained of is the acid and sharp taste. This is imputed to some improper preparation of the rennet, and possibly to something wrong in the feed or pastures. Cheese of good quality is manufactured in Saxony from potatoes. These are boiled, peeled and pulpified with rasps. 1 lb. of sour milk is added to 5 lbs. of this pulp, mixed well and set aside for four days. It is then kneaded, the moisture drained off, and they are potted. They improve by age.

CHEMITYPE. A newly invented style of printing, the object of which is to supersede, to a great extent, wood-cutting. By this method, an etching or engraving made in metal in the usual way, may be converted into a high relieve stamp, to be used for printing on an ordinary press, as is the case with common wood engravings. The following statement may in general illustrate the character of the invention: On a highly polished plate of pure zinc an etching or engraving is made in the usual manner, which, under common circumstances, would be fitted for impressions on an engraver's press, having the same harmony and proportion of all the respective etched or engraved lines. The tracery thus deepened is now to be fused or melted down with a negative metal, and the original metal plate (zinc) corroded, or etched by means of a certain acid, thus making the characters of the former drawing appear in the shape of a high relieve stamp. This effect is only produced in consequence of the metal composition in the lines of the tracery not being acted upon by the acid on account of the galvanic agency subsisting between the two metals, and the acid corroding only the zinc.

As every drawing on the metal plate is completely exact on the relieve stamp, the practice is absolutely independent; the exact and accurate representation of the original sketch is always to be expected. Wood-engraving cannot, in most cases, be superseded by this novel method; but in many other instances the new practice is preferable, chiefly when colored printing is required, in the representation of maps, plans, architectural drawings, &c., &c. At the same time, the correction or improvement of any drawing can be much better executed than in wood-engraving.

CHIMNEY. (Fr. cheminée.) The place in a room where the fire is burnt, and from which the smoke is carried away by means of a conduit called a flue. Chimneys are usually made by projection from a wall, and recess in the same from the floor, ascending within the limits of the projection and recess. That part of the opening which faces the room is properly the *fire-place*, the stone or marble under which is called the *hearth*. That on a level with, and in front of it, is called the *slab*. The vertical sides of the opening are called *jambs*. The head of the fore-plate resting on the jambs is called the *mantel*; and the cavity or hollow from the fire-place to the top of the room is called the *funnel*. The part of the funnel which contracts as it ascends is termed the *gathering*, or by some the *gathering of the wings*. The tube or cavity of a parallelogrammatic form on the plan, from where the gathering ceases up to the top of the chimney, is called the *flue*. The part between the gathering and the flue is called the *throat*. The part of the wall facing the room, and forming one side of the funnel parallel thereto, on the part of the wall forming the sides of the funnels, where there are more than one, is the *breast*. In external walls, that side of the funnel opposite the breast is called the *back*. When there is more than one chimney in the same wall, the solid parts that divide them are called *withs*. And when several chimneys are collected into one mass, it is called a *stack of chimneys*. The part which rises above the roof for discharging the smoke into the air, is called a *chimney shaft*, whose horizontal upper surface is termed the *chimney top*.

The *covings* were formerly placed at right angles to the face of the wall, and the chimney was finished in that manner; but Count Rumford showed that more heat is obtained from the fire by reflexion when the covings are placed in an oblique position. He likewise directed that the fire itself should be kept as near to the hearth as possible, and that the throat of the chimney should be constructed much narrower than had been practised, with a view to prevent the escape of so much heated air as happened with wide throats. If the throat be too near the fire, the draught will be too strong, and the fuel will be wasted; and if it be too high up, the draught will be too languid, and there will be a danger of the smoke being occasionally beat back into the room. Before Count Rumford directed his attention to this subject, smoky chimneys were very common; but by studying his principles, these at present seldom occur.

Lieut. Mason, in a letter to the London *Builder* on the subject of smoky chimneys, writes: "I have built many chimneys in all possible situations, and have found one simple plan everywhere succeeded, the secret being only to construct the throat of the chimney, or that part of it just above the fire-place, so small that a man or a boy can barely pass through it. Immediately above this the chimney should be enlarged to double its width, like a purse, to the extent of about two feet in height, and then diminished again to its usual proportions. No chimney that I ever constructed thus, smoked."

CHINA INK. The finest kind of this useful pigment is seldom met with in our market. According to a description in a Japanese book, it is made from the condensed smoke or soot of burned camphor: and hence, when of the best quality, it has this odor. Most of the China ink is made from oil-lampblack occasionally disguised, as to smell, with musk, or with a little camphor black. The binding substance is gelatine, commonly made from parchment or ass's skin; but isinglass answers equally well. A good imitation may be made by dissolving isinglass in warm water, with the addition of a very little alkali (soda), to destroy its gelatinizing power, and incorporating with that solution, by levigation on a porphyry slab, as much of the finest lampblack as to produce a mass of the proper consistence. The minute quantity of alkali serves also to saponify the oil which usually adheres to lampblack, and thereby to make a pigment readily miscible with water.

CHINTZ. A peculiar pattern on printed calicos, in which flowers and other devices are printed in five or six different colors, upon white and colored grounds. A good chintz pattern in fast colors is one of the most surprizing and difficult efforts of the art.

CHLORAL. A liquid, obtained by the action of chlorine gas upon alcohol.

CHLORATE OF POTASH. A salt composed of chloric acid and potass. It is formed by passing chlorine gas through a solution of caustic potass till no more gas is absorbed, evaporating the liquor and crystallizing. By the action of the gas two salts are formed: a chloride of potassium and a chlorate of potass,—the former remains in solution, the latter crystallizes readily, and it may be separated thus from the chloride. Washing and recrystallization are necessary to obtain a pure salt. Mr. Calvert's improved process consists in forming a mixture of 5¼ ounces of burnt lime for 1 equivalent of caustic potash, and passing a current of chlorine through the hot mixture. In this way chloride of calcium and chlorate of potash are formed. The loss of potash is thus avoided. Chlorate of potash crystallizes in flat, pearly-looking plates, and has an unpleasant cool taste; it does not bleach. It dissolves in six parts of cold water, and when heated to redness, gives out 39 per cent. of oxygen; if rubbed hardly in a mortar, it crackles and gives off sparks. When rubbed with sulphur and phosphorus, it detonates dangerously. A mixture of this salt with sugar and sulphuret of antimony, is used for tipping lucifer matches, as it explodes when rubbed on emery or sand-paper. It formed the detonating powder which was dropped in percussion caps; but owing to the rusting property of the gases produced by explosion, fulminate of mercury is now preferred.

Owing to its property of giving off oxygen readily when decomposed, it has been used to some extent in bleaching fats and oils. It contains 76 parts of chloric acid, and 48 of potassa, in 124 parts of the chlorate.

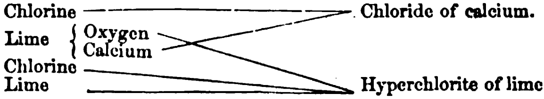
CHLORATES. Combination of chloric acid with salifiable bases.

CHLORIDE OF LIME—BLEACHING POWDER. Its composition is not yet fully determined. The chief agent in bleaching appears to be the hypochlorite of lime, one of the constituents. It constitutes a large branch of chemical manufacture, which is carried on in connection with that of carbonate of soda.

When hydrate of lime, very slightly moist, is exposed to chlorine gas, the latter is eagerly absorbed, and a compound produced which has attracted a great deal of attention: this is the bleaching powder of commerce, now manufactured on an immense scale, for bleaching linen and cotton goods. It is requisite, in preparing this substance, to avoid, with the greatest care, all elevation of temperature, which may be easily done by slowly supplying the chlorine in the first instance. The product, when freshly and well prepared, is a soft, white powder, which attracts moisture from the air, and exhales an odor sensibly different from that of chlorine. It is soluble in about 10 parts of water, merely the unaltered hydrate being left behind; the solution is highly alkaline, and bleaches feebly. When hydrate of lime is suspended in cold water, and chlorine gas transmitted through the mixture, the lime is gradually dissolved, and the same peculiar bleaching compound produced; the alkalies also, either caustic or carbonated, may, by similar means, be made to absorb a large quantity of chlorine, and give rise to corresponding compounds; such are the "disinfecting solutions" of M. Labarraque.

The most consistent view of the constitution of these curious compounds is that which supposes them to contain salts of hydrochlorous acid, a substance as remarkable for bleaching powers as chlorine itself; and this opinion seems borne out by a careful comparison of the properties of the bleaching salts with those of the true hypochlorites. Hypochlorous acid can be actually obtained from good bleaching powder, by distilling it with dilute sulphuric or nitric acid, in quantity insufficient to decompose the whole; when the acid is used in excess, chlorine is disengaged.

If this view be correct, chloride of calcium must be formed simultaneously with the hypochlorite, as in the following diagram:



When the temperature of the hydrate of lime has risen during the absorption of the chlorine, or when the compound has been subsequently exposed to heat, its bleaching properties are impaired, or altogether destroyed; it then contains chlorate of lime and chloride of calcium; oxygen, in variable quantity, is usually set free. The same change seems to ensue by long keeping, even at the common temperature of the air. In an open vessel it is speedily destroyed by the carbonic acid of the atmosphere. Commercial bleaching powder thus constantly varies in value with its age, and with the care originally bestowed upon its preparation; the best may contain about 30 per cent. of available chlorine, easily liberated by an acid, which is, however, far short of the theoretical quantity.

The general method in which this substance is employed for bleaching is the following: The goods are first immersed in a dilute solution of chloride of lime, and then transferred to a vat containing dilute sulphuric acid; the chlorine or hypochlorous acid thus disengaged in contact with the cloth, causes the destruction of the coloring matter. This process is often repeated, it being unsafe to use strong solutions. White patterns are, on this principle, imprinted on colored cloth, the figures being stamped with tartaric acid thickened with gum-water, and then the stuff immersed in the chloride bath, when the parts to which no acid has been applied remain unaltered, while the printed portions are bleached.

For purifying an offensive or infectious atmosphere, *as an aid to proper ventilation*, the bleaching powder is very convenient. The solution is exposed in shallow vessels, or cloths steeped in it are suspended in the apartment, when the carbonic acid of the air slowly decomposes the chloride. An addition of a strong acid causes rapid disengagement of chlorine.

The value of any sample of bleaching powder may be easily determined by the following method, in which the loosely-combined chlorine is estimated by its effect in peroxidizing a proto-salt of iron, of which two equivalents require one of chlorine; the latter acts by decomposing water and liberating a corresponding quantity of oxygen—78 grains of green sulphate of iron are dissolved in about two ounces of water, and acidulated by a few drops of sulphuric or hydrochloric acid; this quantity will require for peroxidation exactly 10 grains of chlorine. Fifty grains of the chloride of lime to be examined are next rubbed up with a little tepid water, and the whole transferred to the alkalimeter before described, which is then filled up to 0 with water, after which the contents are well mixed by agitation. The liquid is next gradually poured into the solution of iron, with constant stirring until the latter has become peroxidized, which may be known by a drop ceasing to give a deep blue precipitate with red ferrocyanide of potassium. The number of grain-measures of the chloride solution employed may then be read off, and since these must contain 10 grains of serviceable chlorine, the quantity of the latter in the 50 grains may be easily reckoned. Thus, suppose

72 such measures have been taken, then

Measures.		Grs. chlorine.		Measures.		Grs. chlorine.
72	:	10	: :	100	:	13·89

The bleaching powder contains, therefore, 27·78 per cent.

A party of Germans have erected in Steubenville, Ohio, an establishment for the manufacture of soda ash and chloride of lime. It is the only one of the kind in the United States; it is estimated that during the first year it will produce between $40,000 and $50,000 worth of soda ash, and nearly $20,000 in value of chloride of lime. It is supposed that the amount of manufacture will be doubled the second year.

CHLORIDES. Combinations of chlorine, corresponding with the oxides. Common salt is a *chloride of sodium*; that is, a binary compound of chlorine and sodium. Where there are two chlorides of the same base, the relative proportions of chlorine in them are almost invariably as 1 to 2: hence the terms *protochloride* and *bichloride*. Calomel and corrosive sublimate are the protochloride and bichloride of mercury. The latter is frequently termed *perchloride*. In calomel, 200 of mercury are combined with 36 of chlorine, and in corrosive sublimate with twice 36, or 72.

CHLORINE. This gas was discovered in 1774 by Scheele, who called it *dephlogisticated muriatic acid*; the French nomenclaturists afterwards termed it *oxygenated muriatic acid*, conceiving it to be a compound of oxygen and muriatic acid. This erroneous view of its nature was corrected in 1809 by Sir H. Davy, who gave it the present name, indicative of its color. Chlorine is a simple substance, existing at common temperatures and pressures in the gaseous state; but when subjected to a pressure of about four atmospheres, it becomes condensed into a yellow transparent liquid, which is a non-conductor of electricity. 100 cubical inches of chlorine, at mean temperature and pressure, weigh between 76 and 77 grains: water absorbs twice its volume, and acquires a yellow color, and the peculiar suffocating odor of the gas. When humid chlorine is exposed to a temperature of 32°, it assumes a crystalline form; this *hydrate of chlorine* consists of 1 equivalent of chlorine = 87 + 10 of water = 9 + 10 or 90. Chlorine is not only unrespirable, but very injurious when breathed, even if largely diluted; a taper burns in it with a red smoky flame, and is soon extinguished. Some of the metals, when finely divided, spontaneously take fire in chlorine, such as brass leaf, or powdered antimony. A remarkable property of chlorine is its power of destroying almost all vegetable and animal colors: hence the important application of this gas and of some of its combinations to the *art of bleaching*. It also destroys the putrid odor of decomposing vegetable and animal substances, and infectious effluvia of all kinds: whence its use in fumigation, and in preventing the spread of infectious and contagious matter, and purifying noxious atmospheres.

The great natural source of chlorine is *common salt*, which contains it in the proportion of about 60 *per cent*. It is procured by decomposing common salt by the joint agency of sulphuric acid and peroxide of manganese. The best proportions are 3 parts of salt and 1 of oxide of manganese; these are well mixed, and put into a retort with 2 parts of sulphuric acid previously diluted with 2 of water. Chlorine is evolved, and its extrication is quickened by the application of a gentle heat. Chlorine may also be obtained from a mixture of muriatic acid with half its weight of black oxide of manganese. The gas may be collected over water, and should be preserved in bottles with glass stoppers; if left in the contact of water, it is soon absorbed. (*See* MURIATIC ACID.)

CHLORIODINE, OR CHLORIODIC ACID. A compound of chlorine and iodine.

CHLORITE. An earthy mineral of a *green* color, often found in the cavities and veins of slate rocks.

CHLOROCARBONIC ACID. A compound formed by exposing a mixture of chlorine and carbonic oxide to the action of light.

CHLOROCYANIC ACID. A compound of chlorine and cyanogen.

CHLOROFORM. A most valuable agent to the physician in producing temporary insensibility to pain: and a still more useful aid in the arts, where it has taken its place as a solvent for many resins, &c. It is obtained by distilling alcohol, woodspirit, or acetone with a solution of chloride of lime. One part of hydrate of lime is suspended in four parts of cold water, and chlorine passed through the mixture until nearly the whole lime is dissolved. A little more hydrate is then added to restore the alkaline reaction, the clear liquid mixed with one part of alcohol or woodspirit, and, after an interval of 24 hours, cautiously distilled in a very spacious vessel.

A watery liquid containing a little spirit, and a heavy oil collect in the receiver; the latter, in which is the chloroform, is agitated with water, digested with chloride of calcium, and rectified in a water-bath. It is a thin, colorless liquid of agreeable ethereal odor, much resembling that of Dutch-liquid, and sweetish taste. Its density is 1·48, and it boils at 141°; the density of its vapor is 4·116. Chloroform is with difficulty kindled, and burns with a greenish flame. It is nearly insoluble in water, and is not affected by concentrated sulphuric acid. Alcoholic solution of potash quickly decomposes it with production of chloride of potassium and formiate of potash.

Chloroform contains $C^2 H Cl^3$; it is changed to formic acid by the substitution of three eq. of oxygen for the three eq. of chlorine removed by the alkaline metal.

It is difficult to obtain pure chloroform. Gregory directs it to be agitated with oil of vitriol and filtered subsequently through oxide of manganese: it will then be free from impurity and keep better.

Chloroform has already been applied to many uses; it is a valuable test for iodine and other bodies in the hand of the chemist: gutta percha dissolved in it, constitutes the *collodion* or artificial skin used by the surgeon in dressing abraded surfaces. It dissolves bromine and the essential oils, gun cotton, caoutchouc, copal and gum lac; and if produced sufficiently cheap, would be a valuable substance in the manufacture of varnishes. The credit of first using substances for producing insensibility, of which ether and chloroform are the chief, belong to this country—having been first applied by Dr. Jackson of Boston, and Mr. Morton.

CHLOROMETER. An instrument for the purpose of testing the decoloring or bleaching powers of *chloride of lime*, by which the relative values of different samples of that important bleaching and disinfecting compound may be ascertained.

CHLOROPHAITE. A mineral, which, when recently broken, is green, but afterwards becomes black.

CHLOROPHANE. A species of fluor spar, which, when heated, shines with a beautiful pale-green light.

CHLOROPHYLL. The green coloring matter of the leaves of plants.

CHOCOLATE is an alimentary preparation of very ancient use in Mexico, from which country it was introduced into Europe by the Spaniards in the year 1520, and by them long kept a secret from the rest of the world. Linnæus was so fond of it, that he gave the specific name, *theobroma* (food of the gods), to the cacoa-tree which produced it. The cacao-beans lie in a fruit somewhat like a cucumber, about 5 inches long and 3¼ thick, which contains from 20 to 30 beans, arranged in 5 regular rows with partitions between, and which are surrounded with a rose-colored spongy substance, like that of water-melons. There are fruits, however, so large as to contain from 40 to 50 beans. Those grown in the West India islands, Berbice and Demarara, are much smaller, and have only from 6 to 15; their development being less perfect than in South America. After the maturation of the fruit, when their green color has changed to a dark-yellow, they are plucked, opened, their beans cleared of the marrowy substance, and spread out to dry in the air. Like almonds, they are covered with a thin skin or husk. In the West Indies, they are immediately packed up for the market when they are dried; but in the Caraccas, they are subjected to a species of slight fermentation, by putting them into tubs or chests, covering them with boards or stones, and turning them over every morning to equalize the operation.

Dr. Ure in his *Dictionary of Arts*, from which this article is condensed, gives an analysis of Guayaquil coco, made by himself, as follows:

Concrete fat or butter of coco, dissolved out by ether....................	87
Brown extractive, extracted by hot water, after the operation of ether..	10
Ligneous matter, with some albumine	30
Shells..............................	14
Water..............................	6
Loss..............................	8
	100

Dr. U. thinks: "the solid fat of the coco should be most intimately combined by milling with the extractive, albumine, and ligneous matter, in order to render it capable of forming an emulsion with water; and, indeed, on account of the large proportion of concrete fat in the beans, some additional substance should be introduce to facilitate this emulsive union of the fat and water. Sugar, gum, and starch or flour, are well adapted for this purpose."

The fatty matter is of the consistence of tallow, white, of a mild agreeable taste, called butter of cacao, and not apt to turn rancid by keeping. It melts only at 122° Fahr., and should, therefore, make tolerable candles. It is soluble in boiling alcohol, but precipitates in the cold. It is obtained by exposing the beans to strong pressure in canvass bags, after they have been steamed or soaked in boiling water for some time. From 5 to 6 ounces of butter may be thus obtained from a pound of cacao. It has a reddish tinge when first expressed, but it becomes white by boiling with water.

The beans, being freed from all spoiled and mouldy portions, are gently roasted over a fire in an iron cylinder, with holes in its ends for allowing the vapors to escape; the apparatus being similar to a coffee-roaster. When the aroma begins to be well developed, the roasting is known to be finished; and the beans must be turned out, cooled, and freed by fanning and sifting from their husks. The kernels are then to be converted into a paste, either by trituration in a mortar heated to 130° F., or by the aid of an ingenious and powerful machine. The chocolate paste has usually in France a little vanilla incorporated with it, and a considerable quantity of sugar, which varies from one-third of its weight to equal parts. For a pound and a half of cacao, one pod of vanilla is sufficient. Chocolate paste improves in its flavor by keeping, and should therefore be made in large quantities at a time. But the roasted beans soon lose their aroma, if exposed to the air.

CHROMATYPE, is a new process of photography. It consists in washing good letter-paper with the following solution:—Bichromate of potash, 10 grains; sulphate of copper, 20 grains; distilled water, 1 ounce. Papers prepared with this are of a pale-yellow color, and may be kept for any length of time without injury, and are always ready for use. For copying botanical specimens, or engravings, nothing can be more beautiful. After the paper has been exposed to the influence of sunshine, with the object to be copied superposed, it is washed over in the dark with a solution of nitrate of silver of moderate strength; as soon as this is done a very vivid positive picture makes its appearance, which then only requires washing in pure water.

CHROMIUM, (*Chrome.*) A metal discovered by Vauquelin in 1797. It exists chiefly in two native compounds; the one formerly called *red lead* of Siberia, which is a *chromate of lead;* the other, a compound of the oxides of chromium and iron. Chromium is a whitish, brittle, and very infusible metal; sp. gr. 5·5. When heated with nitre, it is converted into *chromic acid.* Its equivalent number is 28. It forms two compounds with oxygen,—a green oxide, and a red peroxide; the latter being sour, and combining with salefiable bases, is called *chromic acid.* The oxide consists of 28 chromium + 12 oxygen; and chromic acid of 28 chromium + 24 oxygen. Chromic acid is of a red color, and forms a variety of *colored* compounds, some of which are much used in the arts; such as the *chromate* and *bichromate of potash,* largely manufactured for the use of calico-printers, and the *chromates of lead,* employed as yellow and red dyes and paints. The oxide of chrome is green, and furnishes a valuable color for porcelain and in enamel. Chromic acid gives color to the ruby, and the green of the emerald is due to oxide of chrome.

Chrome iron ore is found in abundance distributed over the United States. In Maryland, at the Bare Hills near Baltimore; and in Delaware county, Pa., it is found very plentifully. In that locality, one firm has upwards of 100 hands employed, and are daily shipping the mineral to Baltimore. The proprietors of farms upon which it is found, receive $3 per ton for washed chrome—and in the rock state it is sometimes worth $5 per ton. Mr. Wood's chrome iron ore mine, on the River Ortorara, separating Chester and Lancaster counties, Pa., is probably the most extensive chrome mine in the world, being 170 feet deep—200 feet long and 30 feet broad: the ore yields 98 per cent. of oxide of chrome. The mineral is also found in great abundance at various points east of the Mine Ridge, in Lancaster, Chester, and Delaware counties, Pa., and is all, or nearly all, shipped to Baltimore, whence it is exported largely to Europe. This ore forms the basis of many of the colored preparations of chrome, for which *see* DYEING.

The chief application of this ore is to the production of chromate of potash, from which salt the various other preparations of this metal used in the arts are obtained. The ore, freed, as well as possible, from its gangue, is reduced to a fine powder, by being ground in a mill under ponderous edge-wheels, and sifted. It is then mixed with one-third or one-half its weight of coarsely bruised nitre, and exposed to a powerful heat, for several hours, on a reverberatory hearth, where it is stirred about occasionally. In the large manufactories of this country, the ignition of the above mixture in pots is laid aside, as too operose and expensive. The calcined matter is raked out, and lixiviated with water. The bright-yellow solution is then evaporated briskly, and the chromate of potash falls down in the form of a granular salt, which is lifted out from time to time from the bottom with a large ladle, perforated with small holes, and thrown into a draining-box. This saline powder may be formed into regular crystals of neutral chromate of potash, by solution in water and slow evaporation; or it may be converted into a more beautiful crystalline body, the bichromate of potash, by treating its concentrated solution with nitric, muriatic, sulphuric, or acetic acid, or, indeed, any acid exercising a stronger affinity for the second atom of the potash than the chromic acid does.

Bichromate of potash, by evaporation of the above solution, and slow cooling, may be obtained in the form of square tables, with bevelled edges, or flat four-sided prisms. They are permanent in the air, have a metallic and bitter taste, and dissolve in about one-tenth of their weight of water, at 60° F.; but in one-half of their weight of boiling water. They consist of chromic acid 13, potash 6; or, in 100 parts, 68·4 + 31·6. This salt is much employed in calico-printing and in dyeing; which see.

Chromate of lead, the chrome-yellow of the painter, is a rich pigment of various shades, from deep orange to the palest canary-yellow. It is made by adding a limpid solution of the neutral chromate (the above granular salt) to a solution, equally limpid, of acetate or nitrate of lead. A precipitate falls, which must be well washed, and carefully dried out of the reach of any sulphureted vapors. A lighter shade of yellow is obtained by mixing some solution of alum, or sulphuric acid, with the chromate, before pouring it into the solution of lead; and an orange tint is to be procured by the addition of subacetate of lead, in any desired proportion.

Lately great use has been made of the green oxyde to dyeing and painting on porcelain. This oxyde may be prepared by decomposing, with heat, the chromate of mercury, a salt made by adding to nitrate of protoxyde of mercury, chromate of potash, in equivalent proportions. This chromate has a fine cinnabar red, when pure; and, at a dull red heat, parts with a portion of its oxygen and its mercurial oxyde. From M. Dulong's experiments it would appear, that the purest chromate of mercury is not the best adapted for preparing the oxyde of chrome to be used in porcelain painting. he thinks it ought to contain a little oxyde of manganese and chromate of potash, to afford a green color of a fine tint, especially for pieces that are to receive a powerful heat. Pure oxyde of chrome preserves its color well enough in a muffle furnace; but, under a stronger fire, it takes a dead-leaf color.

An improved method of making this valuable color for enamelling, is to mix intimately 45 parts of gunpowder with 240 parts of perfectly dry chromate of potash, and 35 parts of hydrochlorate of ammonia (sal ammoniac), reduce to powder, and pass through a fine sieve; fill a conical glass or other mould with this powder, gently pressed, and invert so as to leave the powder on a porcelain slab of any kind. When set on fire at its apex with a lighted match, it will burn down to the bottom with brilliant coruscations. The black residum, being elutriated with warm water, affords a fine bright green oxide of chromium.

CHROMIC ACID. As this substance is now much used by calico printers and bleachers, the following mode of obtaining it is subjoined. To 100 parts of yellow chromate of potash, add 136 of nitrate of barytes, each in solution. A precipitate of the yellow chromate of barytes falls, which being washed and dried would amount to 130 parts. But while still moist it is to be dissolved in water by the intervention of a little nitric acid, and then decomposed by the addition of the requisite quantity of sulphuric acid, whereby the barytes is separated, and the chromic acid remains associated with the nitric acid, from which it can be freed by evaporation to dryness. On re-dissolving the chromic acid residum in water, filtering and evaporating to a proper degree, 50 parts of chromic acid may be obtained in crystals.

This acid may also be obtained from chromate of lime, formed by mixing chromate of potash and muriate of lime; washing the insoluble chromate of lime which precipitates, and decomposing it by the equivalent quantity of oxalic acid, or for ordinary purposes even sulphuric acid may be employed.

Chromic acid is obtained in quadrangular crystals, of a deep red color; it has a very acrid and styptic taste. It reddens powerfully litmus paper. It is deliquescent in the air. When heated to redness it emits oxygen, and passes into the deutoxyde. When a little of it is fused along with vitreous borax, the compound assumes an emerald green color.

CHRONOGRAPH, LOCKE'S ELECTRO C. This apparatus, for which an appropriation was made by Congress, has been put in operation at the National Observatory Washington.

The clock case is of fine Italian marble, ornamented with glass panels, set in silver sashes. The dial and hands are like those of an ordinary clock, but the dial is cut out and made a skeleton, for the purpose of giving access to the electrical works behind it. The pendulum is made throughout of glass ; to compensate for the expansion even of glass by heat, the weight of the pendulum consists of four large glass tubes, placed side by side, like organ pipes, all filled four or five inches deep with quicksilver. The suspension of the pendulum consists of hardened steel cylinders, rolling on jewelled planes made of polished chrysolite. The mechanism by which the electrical contact surfaces are kept clean and bright is very ingenious and was suggested to Dr. Locke by Prof. House of New York. It consists of a small platinum cylinder which is kept revolving with a wiper to keep it clean. This cylinder has also a longitudinal motion, which by reciprocation makes the electrical contacts, which occur every second, travel in a spiral, which also revolves. The result is, that the contacts are made every second for 36 days without occuring twice in the same place; and even then it is a mere chance if the contacts are recommenced in the same track.

Every time a contact is made a slight mark is left, by electrical action, on the platinum surface ; and when the spiral revolution has been completed, the cylinder is marked all over its surface by geometric intersections.

The clock contains a duplicate interrupter or electrotome, which may be brought into action when desired. It consists of a little tilt-hammer, pivoted concentrically with the pendulum, and lifted by a little arm, or its equivalent, projecting from the pendulum itself.

No less than four patents have been recently taken out in England for improvements in Clocks moved by Electricity. The first Electric Clock known was invented in 1815, by a German named Buzengeiger. This was a local clock. The first Electric Clock to move in unison any number however distant, was invented by Bain in 1840. Since then there have been a great number of modifications such as combining a register with the clock, which is a most important improvement.

CHRONOMETER. A watch of peculiar construction, and great perfection of workmanship, used for determining geographical longitudes, or other purposes where time must be measured with extreme accuracy. The chronometer differs from the ordinary watch in the principle of its escapement, which is so constructed that the balance is entirely free from the wheels during the greater part of its vibration ; and also in having the balance compensated for variations of temperature. Marine chronometers generally beat half seconds, and are hung in gimbals, in boxes about six or eight inches square. The pocket chronometer does not differ in appearance from the ordinary watch, excepting that it is generally a little larger. Chronometers are of immense utility in navigation ; and ships going on distant voyages are usually furnished with several, for the purpose of checking one another, and also to guard against the effects of accidental derangement in any single one. The accuracy whith which some of the better sort of chronometers have been found to perform is truly astonishing ; the error in a two months' voyage not exceeding two or three seconds.

Chronometers, offered to the British Government to purchase, are placed in the Greenwich Observatory in the first or second week in January, and ranged on shelves round the chronometer room, and each is daily compared with the astronomical clock, and its rate carefully noted. This is continued until the middle of July, during which time the temperature of the room is much varied. In the coldest weather the room is thrown open, so that it is as cold inside as out ; and in summer the change is all of 70° of difference. The chronometers are also submitted day and night for about six weeks to 80 degrees heat, raised by fire. This is the usual trial.

Chronometers are more in use in American vessels than in those of any other nation.

Mr. Loseby has introduced mercury into the chronometer to compensate for the loss of elasticity in the balance spring when subjected to heat. It acts equally by its fluidity and by its thermal expansion, and has been favorably reported on after trial, by the Astronomer Royal of England.

CHRYSOBERIL. This mineral occurs in small rounded masses, and in crystals, it is very hard, transparent or translucent, and of different shades of greenish yellow. It is employed in jewelry. It has been brought from Brazil; and is associated in the sand of the Ceylonese rivers with rubies and sapphires. The *cymophane* of Hauy, which is a species of chrysoberil, consists of alumina 76·7, glucina 17·8, oxide of iron 5·5.

CHRYSOLITE. A crystallized mineral, often of a golden yellow color. It is a ferriferous *silicate of magnesia*, and is sometimes used in jewelry.

CHURN. An instrument used to separate the butter out of milk. So long as the milk is alkaline the butter will not separate, but when it becomes faintly acid the butter commences to gather on the top. Agitating the milk by introducing air hastens this by forming lactic and acetic acids in the milk.

In 1850 Mr. Z. C. Robins of St. Louis, Mo., patented a telegraph churn, of which the following figure is an illustration.

The nature of this invention is to agitate the cream or milk by the operation of the rotation of the beaters, (formed for that purpose) like to the action produced by knives for whipping eggs. The specification says:—

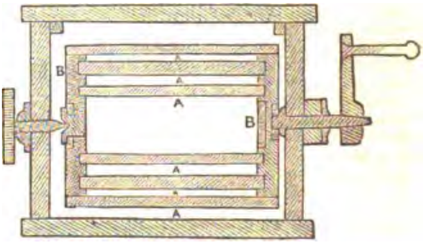
I produce this effect by forming the beaters on the agitator, of thin slats or boards, A A, secured to radial arms, B B, or discs, in such positions as to bring their sides at right angles, or nearly so, with the radii of the agitator. I generally construct the agitator of four series of beaters, as represented in the drawings, each series being composed of two, three or more beaters, one placed within the other, with narrow spaces between each beater.

Unless the agitator is driven at a high velocity, the particles of milk, &c., are not thrown off tangentially. It can operate in a round vessel as well as a square one, and produces butter at the usual temperature, in about ten minutes. When the butter has been made, it is collected into a roll in the centre, by reversing the motion.

The wording of his claim is: "What I claim is the series of parallel floats or beaters A A, formed and arranged within the agitator, substantially as above described, so that when their motion is reversed, their thick inclined rear edges will gather the butter into a roll in the centre of the agitator, substantially as herein set forth."

CIDER. A fermented liquor made from the juice of apples. Cider is made in all the temperate climates of the world which are not sufficiently warm for maturing the grape, and where the cold is not so great as to reduce the inhabitants to only the beer produced by a fermented decoction of grain. Cider is formed by grinding or crushing the apples when ripe, either in a circular stone trough by a stone roller turned by a horse, or between fluted or spiky, and afterwards between smooth rollers of wood or iron, driven by men. The apples, including the core and the seeds, being reduced to a pulp by crushing or grinding, the mass is put into a hair cloth and powerfully pressed; and the liquor which runs from it is put into casks, where it is allowed to ferment, the casks being freely exposed to the air in the shade; the progress of the fermentation is then carefully watched, and as the sediment has subsided the liquor is racked off; on the proper time being chosen for doing this depends the excellence of the cider. The best cider, other circumstances being the same, is that in which the fermentation has gone on slowly, and where the vinous fermentation has not gone so far as to become acetous. The check to fermentation consists in racking off from one cask to another. Before winter the casks are removed to a cellar, and by the following spring the liquor is fit for use, or bottling.

The value of apples to produce this beverage of good quality is proportionate to the specific gravity of their juice. M.



Converchel has given the following table, illustrative of that proposition:—

Juice of the green renette, queen apple (*reinette verte*)	1,084
English renette	1,080
Red renette	1,072
Musk renette	1,069
Fouillet rayé	1,064
Orange apple	1,063
Renette of Caux	1,060
Water	1,000

In November.2, 340 kilogrammes of apples (2¼ tons English, nearly) are supposed to afford 1,000 litres (220¼ gallons) of pure cider; and 600 litres of a small cider made with the marc mixed with water and pressed. But many persons mix all together, and thus manufacture 1,600 litres out of the above weight of fruit. In France, the fermented liquor, as soon as it is clear, is often racked off into casks containing the fumes of burning sulphur, whereby it ceases to ferment, and preserves much of its sugar undecomposed. It is soon afterwards bottled. Average cider should yield 6 per cent. of alcohol on distillation.

Cider-apples may be distributed into three classes, the sweet, the bitter, and the sour. The second are the best; they afford a denser juice, richer in sugar, which clarifies well, and when fermented keeps a long time; the juice of sweet apples is difficult to clarify; but that of the sour ones makes bad cider. Late apples are in general to be preferred.

Frederick Falkener, in the fourth volume of the Royal Agricultural Journal of England, adverts judiciously to the necessity of the presence of alkaline and earthy bases, in the soils of all deciduous trees, and especially of such as produce acid fruits.

CINNABAR. An Indian name, given, according to Pliny, to a mixture of the blood of the dragon and elephant, and other substances of similar color. It is now exclusively applied to the red pigment called *vermilion*. It is a *bisulphuret of mercury*, composed of 200 mercury+32 sulphur.

CINNAMON. The bark of the *Cinnamomum zeylanicum*. This tree is a native of Ceylon, whence the finest cinnamon is obtained; it is of an astringent and highly aromatic and warm flavor, and yields by distillation an extremely fragrant and pungent volatile oil, kept for pharmaceutical use under the name of *oil of cinnamon*. An inferior kind of cinnamon is often met with in commerce, which is remarkably deficient in flavor.

CINNAMON STONE. (So called from its color.) A silicate of lime, alumine, and oxide of iron, from Ceylon. It occurs massive and in rounded pieces in the sand of rivers; some of these are occasionally cut and polished for jewelry.

CITRIC ACID. The acid of lime and lemon juice. It is largely made for domestic use and for calico printing. The juice is saturated with lime to separate the mucilage and extraneous matters. The citrate of lime so formed is treated with oil of vitriol, which taking the lime to form sulphate of lime sets the citric acid free: this is treated with water, and evaporated and crystallized.

CIVET. A brown semifluid contained in a gland near the anus of the Viverra Civetta or civet cat. The odor, unless dilute, is very unpleasant, combined with other perfumes.

CLARET. A term applied to several of the Bordeaux wines. An excellent claret is now manufactured in Texas from the Mustang grape. As many as five barrels have been made upon a single plantation. The spontaneous production of this grape in Texas exceeds all belief. Thousands of hogsheads of wine, nowise inferior to French claret, could be manufactured every year from this hardy native grape.

CLAY. In chemistry, a term generally applied to a variety of *plastic* earthy compounds of different colors, and having much attraction for water. They are essential in the manufacture of pottery, and consist of silica, with variable quantities of alumina, and generally some oxide of iron.

CLAY. In agriculture, one of the most common ingredients that enter into the composition of soils. Indeed, it may be asserted that no soil whatever will maintain its fertility for any length of time without a due proportion of clay in its composition. The most fertile soils in the world are the alluvial deposits on the banks of rivers; and these, in an agricultural sense, all belong to clayey soil. In many cases the clays of agriculture are intimately united with calcareous earths, and in others with sands; but in both cases these earths are in such a state of minute division, that the mixture has all the appearance and the mechanical properties of a strong clay, and they are treated by cultivators accordingly; and these, when examined, are found in many cases to contain a considerable proportion of lime, and in others of sand. The best wheats are every where grown on calcareous clays; and also the best fruits and flowers of the Rosaceous kind, such as apples, pears, plums, cherries, roses, &c.; but it is remarkable that the grape, when grown on clayey soil, produces neither high-flavored fruit nor good wine.

CLAYEY SOIL. Soil in which clay is the principal earthy ingredient. Soils of this description when first subjected to cultivation are expensive to labor, and uncertain in their produce; but after they have been drained, cultivated, limed, and manured for two or three generations, they become the most fertile of all soils, producing immense crops of wheat, beans, clover, rye-grass, &c.

CLOCK. (*See* Watch.)

CLOTH. (*See* Textile Fabrics and Weaving.)

Cloth, *incombustible.* At a late meeting of the British Association, Sir David Brewster read a paper "On a specimen of incombustible cloth, for the dresses of ladies and children, manufactured in Dundee, Scotland, by Mr. Latts." This cloth is printed calico, of which several specimens were prepared by immersion in phosphate of magnesia. When inflamed it soon went out without the flame spreading, and Sir David stated that a spark of red coal would not ignite it.

Cloth, *Vulcanized India Rubber* (patented). Mix 15 parts of golden sulphuret of antimony with 100 parts of India rubber, and when it is thoroughly "masticated" as known to manufacturers, the articles are to be made up and then submitted to heat in a boiler under pressure at a temperature varying from 260° to 280° Fahrenheit.

Cloth, *or Silk French Waterproof.* The following is the process adopted by M. Collet:—Take 1 lb. of linseed oil, 1¼ lb. of white lead, 1 oz. of umber, and a little garlic; boil these ingredients for 12 hours over a slow fire, and when this composition acquires a skin upon its surface, it is fit for use. The cloth or silk is then to be immersed, being previously spread over a frame, then hung up to dry, and afterwards rubbed smooth with pumice stone.

The material is next to be coated with another composition, prepared in the following manner:—Take 1 lb. of linseed oil, 1 oz. litharge, 4 drachms of sulphate of zinc, and 4 oz. of white lead, calcined to a yellow color: boil these in an iron pot until they assume the consistence of paste. This preparation is then to be spread over the cloth on the side of it, and then dried in a heated chamber. For covering of silk this operation should be repeated. Oil-skin cloth, perfectly flexible and waterproof, is thus produced.

COAL. This highly important substance is found in beds or strata in that group of the secondary rocks which includes the red sandstone and mountain limestone formations, and which is commonly called the *carboniferous group*, or *coal measures.* From the peculiarities of their depositions they are often spoken of under the names of *coal basins*, and *coal fields.* There are two or three points, and those of much theoretical importance, respecting the origin of coal, on which geological authorities are nearly unanimous. The one is, that our present coal is exclusively of vegetable origin, formed apparently from the destruction of vast forests; and the prodigious quantities of timber drifted by some of the great rivers of the world into the present ocean render it not improbable that a similar formation may now be carrying on in the depths of certain parts of the sea. Secondly, from the nature of the preserved vegetables it appears probable that the climate of these parts was not merely tropical, but ultratropical. It may also be inferred that the coal strata were deposited in the neighborhood, and often probably upon the very verge of extensive tracts of dry land; for the trees that are found in coal strata are often like those of *our* submarine forests, as far as position goes. And, finally, the deposits of coal appear afterwards to have been elevated, and often singularly dislocated and contorted by forces acting from below, and probably of a volcanic nature.

In some coal fields there are appearances which justify the term *coal basin*: they are of limited extent, frequently dip as it were to a common centre, and consist of various beds of sandstone, shale, and coal, irregularly stratified; and sometimes mixed with conglomerates, showing a mechanical origin.

That these deposites have taken place, and that the change of wood into coal has often been effected under great pressure, and often under the pressure of heat, seems evident from the appearance of some of the vegetable masses, and also from the manner in which the carburetted hydrogen escapes in the form of *blowers* and eructations from the strata, as if pent up in their cavities under vast condensation, and even sometimes, perhaps, in a liquid form.

Though there are often many beds and

seams of coal in one field, it is seldom that many of them are worked. They are generally of uniform thickness through a great extent, but are sometimes subject to irregularities. When less than two feet thick they are seldom worked to any great extent. The nature of the upper stratum, or stony matter of the *roof*, is very important: if compact, it is secure from falling, and keeps out water; if loose, the expenses incurred in supporting it absorbs the profits of the coal.

The Beds of Coal in the U. S. are numerous and extensive, embracing the whole country from the border of New Brunswick to Tuscaloosa in Alabama, and from the Alleghanies to Vancouver's Island. The coal is of both kinds, anthracitic and bituminous. The former existing on the slope of the Alleghanies, where, by upheaval of heated mineral masses, the bitumen has been expelled, and the coal converted into anthracite. The bitumen in coal increases as the beds pass westward toward the Mississippi, where as well as on the Pacific shores, the quantity of bitumen is equal to that in English sea-coal. The geological survey of the state of New York has not brought to light any important deposit of coal in that state; but it has been stated in the *Albany Evening Journal* of 1850, that a seam of coal, four feet in thickness, has been discovered by Mr. J. N. Cutler, of that city, in Coeymans—a few miles only from Albany, on the farm of a Mr. Vanduzee. It is believed to extend through Albany, Green, and Schoharie counties.

The three great coal-fields in the country are:—the Ohio, 740 miles long, and 180 wide, covering an area of 60,000 square miles; the Illinois coal-field, covering 50,000 square miles; and the Michigan, 15,000 square miles. Besides these, there are the numerous anthracitic basins in Pennsylvania and Virginia, the furthest being 100 miles S.E. of the margin of the Ohio coal-field. In passing across the coal-fields there is a gradual diminution of the bitumen eastward. The coal of *every kind* rests on the same basis of rock, with the same fossils distributed through it, and the particular coal-fields can be identified even when separated by an interval of 50 miles. The anthracite field is 5000 feet deep, and contains 50 seams of coal. The bituminous coal-field of Ohio is 2,800 feet deep, 8,000,000 tons of anthracite, and 1,000,000 tons of bituminous coal are raised yearly. The anthracite coal-mines on the Lehigh River, Pa., are worked like an open quarry on the slope of a mountain, rising 900 feet above the river. The coal is 60 feet thick, and surrounds the quarry in black glistening walls, capped by 40 feet of yellow sandstone, and is conveyed by a self-acting railway for eight miles down a declivity, from 100 to 140 feet per mile, the whole of obtaining being about 4 cents a ton; when quarried to some distance the bed splits up into branches. The anthracite district extends across two counties, Luzerne and Schuylkill. At Portsmouth, R. I., a bed of anthracite has been worked for 25 years back. A mine of anthracite has been open in Worcester, Mass., at the head of the Blackstone Canal. The cost of transport of a ton of coal is—

From Maunch Chunk to Philadelphia	$1 93
From Maunch Chunk to New York .	2 42
From Penham to Philadelphia . .	1 93
From Penham to New York . .	2 55

The value of coal exported in 1850 was $167,090. The coal imported in the same year was 180,439 tons, value $378,817.

COBALT. From *Kobold*, "evil influence," applied by the German miners, who considered it unfavorable to the presence of the more important metals.

Cobalt is a brittle metal of a reddish gray color; its specific gravity is 7·8. It fuses at a temperature a little below that required for the fusion of iron. It is magnetic. When heated red hot, and freely exposed to air, cobalt absorbs oxygen. Its equivalent number is 30; and the salifiable, or protoxide of cobalt, consists of 30 cobalt + 8 oxygen = 38 oxide of cobalt. The oxide of cobalt is nearly black; but when in the state of hydrate, or when largely diluted by fusion with glass or borax, it produces its characteristic blue color; and as this color is permanent at very high temperatures, it is an invaluable article in the manufacture of porcelain and pottery, all the blue colors of which are derived from oxide of cobalt. When fused with glass it communicates a blue tint without impairing its transparency. A very deep blue glass of this kind when finely powdered acquires a pale and brilliant color, and is called *smalt*. Impure oxide of cobalt is known in commerce under the name of *zaffre*. Cobalt is said by Stromeyer to exist in all meteoric iron, although in very small quantity. In its ores it is always associated with arsenic, and zaffre is prepared by roasting these native arseniurets of cobalt.

COCCOLITE. A mineral of a concretional or granular texture.

COCOON. The silken case which the larvæ of certain insects spin for the purpose of a covering during the period of their metamorphosis, and which some spiders prepare as a protection to their ova during the development of the young. The cod or cocoon of the silkworm is a well known example of the most valuable of these productions.

COCCULUS INDICUS. The fruit of the *Menispermum cocculus*, imported from the East Indies. It contains a poisonous principle, which has been termed *picrotoxia*. It is often used to poison fishes; a few handfuls of it ground into coarse powder, and thrown into a pond, bring the fish, in the course of a few hours, to the surface in an intoxicated or poisoned state; but if quickly removed into fresh water, they recover. It is sometimes added to ale to increase its stupefying quality.

COCHINEAL. The *Coccus cacti.* This valuable insect was first introduced into Europe about the year 1523. It is imported from Mexico and New Spain. It feeds on several species of cactus. It is small, rugose, and of a deep mulberry color. They are scraped from the plants into bags, killed by boiling water, and dried in the sun. Those are preferred which are plump, of a peculiar silvery appearance, and which yield a brilliant crimson when rubbed to powder. Cochineal is sometimes adultered by the admixture of a manufactured article composed of colored dough. This is detected by the action of boiling water, which dissolves and disintegrates the imitation, but has little effect upon the real insect. The principal component of cochineal is a peculiar coloring matter, which has been called *carminium* and *cochinelia.* It is obtained by digesting the powder of cochineal first in ether, which takes up fat, and then in alcohol, which dissolves the cochinelia. Acids change its color from crimson to an orange red, and alkalies turn it violet. When mixed with recently precipitated aluminous earth, it forms a beautiful lake. Cochineal yields a brilliant scarlet dye, which is produced by fixing the coloring matter of the insect by a mordant of alumina and oxide of tin, and exalting the color by the action of supertartrate of potash. (*See* CARMINE and DYEING.)

COCOA, MANUFACTURES FROM. The cocoa manufactures are remarkable for simplicity of the process resorted to, and for the usefulness of the articles produced, in many instances, from materials formerly thrown away as useless. The cocoa nut as it comes from the tree consists, first, of the outer husk, composed of fibres matted and adhering together; secondly, the shell; and thirdly, the kernel. The manufacturers up to the present time employed only the outer husk and kernel. The natives of India have long used the fibres obtained by rotting the outer husk till the fibres can be separated by beating the husks. The fibres are spun into yarn by the native girls and women, by rubbing such fibres between the palm of the hand and the surface of the leg; and in this manner is made the large quantity of Coir yarn brought into that country, and used for weaving-cloths for covering passages and rooms, and also matting for various uses. Notwithstanding this rude mode of spinning the fibres, up to the present time no better means have yet been introduced; and the whole of the yarn employed in England is imported. This, however, may be accounted for, by reason of there having been no practical mode of obtaining the fibre in Britain from the husks till very lately. The husks are beaten to obtain the fibre, which consists of three descriptions: first, a light elastic fibre suitable for stuffing furniture; secondly, a coarser fibre used for making mats; and thirdly, a strong fibre used for brushes and brooms. The husks are soaked for some time, then subjected to the pressure of grooved rollers, and then by successive processes of carding, by revolving cylinders armed with bent teeth, the fibres are combed out, the separate descriptions of fibres being deposited in different receivers. The uses of these fibres are for making brushes, brooms, mats, and mattresses. The kernels are dried in the sun, then pounded in mills to extract the oil; but in more modern times the dried kernel has been pressed between mats in powerful presses. The oil for the most part is sent to England, and was formerly largely employed in the manufacturing of candles. The oil being, when it comes to London, of about the consistency of lard, requires pressing to separate the stearine from the elaine, and this is done between mats of cocoa nut fibre pressed in powerful presses. The stearine was used for candles at first alone, then in combination with stearic acid of tallow, producing what are called composite candles; and it was the introduction of stearine of cocoa nut, combined with stearic acid, which constituted the first step to the great improvement which has taken place in the manufacture of candles. The larger quantities of cocoa nut oil, however, are now exported to France to make soap, the use of such oil in candle making being now for the most part substituted by palm oil. It has lately been proposed in Ceylon, to employ the juice of the cocoa nut tree for the making of sugar, it being considered that each tree is capable of producing upwards of one hundred weight per annum, and that an acre of cocoa nut trees, requiring little cultivation, will produce at least twice as much sugar as an acre of sugar-cane requiring much more cultivation.

COFFEE. The seed of an evergreen shrub, *coffea Arabica*, of the family *Rubiaceæ*. It rises twenty feet high. The berry is imported from Arabia, the East and West Indies. In Java large quantities are grown and exported.

It grows upon large bushes, and the grains of coffee are formed two in a berry, about the size and shape of our common plum. The skin of the berry is about as thick as that of the plum, and the color, when ripe, a pale scarlet.

The bush is very productive. Every branch is loaded with the berries, which grow two in a place, on the opposite sides of each other, and about an inch and a half apart. When ripe, the skin bursts open, and the grains of coffee fall out upon the ground; but a more general way is to spread something under the bush, and shake the coffee down. After the outer skin is taken off there remains a kind of husk over each kernel, which is broken off (after being well dried in the sun) by heavy rollers. The coffee after this needs winnowing, in order to be freed from the broken particles of the bush. It has been said by some writers that one bush will not, with another, average more than a pound of coffee.

Coffee might be cultivated with advantage in Florida.

The analysis of the raw berry affords

Cellular matter,	34
Moisture,	12
Fatty matters,	10 to 13
Glucose dextrin,	15·5
Legumen and casein,	3
Caffein,	3·5 to 5
Nitrogenized matters,	8
Essential oil and aromatic principles,	·005
Potash, lime, magnesia, phosphoric and sulphuric acids, silica and chlorine,	6·697

In 100 parts.

The change coffee undergoes by roasting is not fully understood; some of the essential oils are driven off, and the berry is charred; the peculiar aroma is developed, which is soluble in water, and is acid.

COKE. The charcoal obtained by heating coal with the imperfect access of air, or by its distillation. The former is usually called *oven coke;* the latter *gas coke*, being abundantly produced in gas-works. The weight of coke usually amounts to between 60 and 70 *per cent.* of the coal employed. Coke is a valuable fuel for many purposes in the arts.

COLCOTHAR. Brown peroxide of iron. (*See* ROUGE.)

COLOPHANY. The dark colored resin which remains after the distillation of oil of turpentine.

COLUMBIUM. A metal discovered by Mr. Hatchett in 1801, in a mineral from Massachusetts in North America. It has since been found in a Swedish mineral called tantalite, but its ores are extremely rare. It is acidifiable, and hence the peroxide has been termed *Columbic acid.*

COLZA, OIL OF. The oil expressed from the seed of the *Brassica oleracea*, a species of cabbage. Colza oil is much used in France and Belgium for burning in lamps and other purposes.

COMB. The name of an instrument made of a thin plate, either plane or curved of wood, horn, tortoise-shell, ivory, bone, or metal, cut out upon one or both of its sides or edges, into a series of somewhat long teeth, not far apart; which is employed for disentangling, laying parallel and smooth the hairs of man, horses, or other animals.

A thin steel saw bow, mounted in an iron or wooden handle, is the implement used by the comb-maker to cut the bone, ivory, and wood, into slices of from a twelfth to a quarter of an inch thick, and of a size suitable to that of the comb. The pieces of tortoise-shell as found in commerce are never flat, or, indeed, of any regular curvature, such as the comb must have. They are therefore steeped in boiling water sufficiently long to soften them, and set to cool in a press between iron and brass moulds, which impart to them the desired form which they preserve after cooling. After receiving their outline shape and curvature, by proper flat files or fine rasps, the place of the teeth is marked with a triangular file, and then the teeth themselves are cut out with a double saw, composed of two thin slips of tempered steel, such as the main-spring of a watch, notched with very fine sharp teeth. These slips are mounted in a wooden or iron stock or handle, in which they may be placed at different distances, to suit the width of the comb-teeth. A comb-maker, however, well provided in tools, has an assortment of double saws set at every ordinary width. The two slips of this saw have their teeth in different planes, so that when it begins to cut, the most prominent slip alone acts; and when the teeth of this one have fairly entered into the comb, the other parallel blade begins to saw. The workman, meanwhile, has fixed the plate of tortoise-shell or ivory between the flat jaws of two pieces of wood, like a vice made fast to a bench, so that the comb intended to be cut is placed at an angle of 45° with the horizon. He now saws perpendicularly, forming two teeth at a time, proceeding truly in the direction of the first tracing.

Dr. Ure mentions a much better mode of making combs, which is to fix upon a shaft or arbor in a lathe a series of circular saws, with intervening brass washers or discs to keep them at suitable distances; to set in a frame like a vice, in front of these saws, the piece of ivory or horn to be cut; and to press it forward upon the saws at an angle of 45 degrees, by means of a regulated screw motion. When the teeth are thus cut, they are smoothed and polished with files, and by rubbing with pumice-stone and tripoli.

Mr. Bundy, of Camden Town, England, obtained a patent so long ago as 1796, for an apparatus of that kind, which had an additional arbor fitted with a series of circular saws, or rather files, for sharpening the points of the comb-teeth.

More recently, Mr. Lyne has invented a machine in which, by means of pressure, two combs are cut out at once with chisels from any tough material, such as horn or tortoise-shell, somewhat softened at the moment by the application of a heated iron to it. The piece of horn is made fast to a carriage, which is moved forward by means of a screw until it comes under the action of a ratchet-wheel, toothed upon a part of its circumference. The teeth of this wheel bring a lever into action, furnished with a chisel or knife, which cuts out a double comb from the flat piece, the teeth of which combs are opposite to each other. By this means, no part of the substance is lost, as in sawing out combs. The same carriage may be used, also, to bear a piece of ivory in the hard state toward a circular saw, on the principles above explained, with such precision, that from 80 to 100 teeth can be formed in the space of one inch by a proper disposition of the tool.

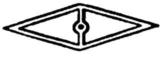
Bullocks' horns, after the tips are sawed off, are roasted in the flame of a wood fire, till they are sufficiently softened; when they are slit up, pressed in a machine between two iron plates, and then plunged into a trough of cold water, whereby they are hardened. A paste of quicklime, litharge, and water, is used to stain the horn to resemble tortoise-shell.

COMBINATION. A chemical term which denotes the intimate union of dissimilar particles of matter into a homogeneous-looking compound, possessed of properties generally different from those of the separate constituents.

COMBUSTIBLE. Any substance which, exposed in the air to a certain temperature, consumes spontaneously with the emission of heat and light. All such combustibles as are cheap enough for common use go under the name of Fuel; which see. Every combustible requires a peculiar pitch of temperature to be kindled, called its *accendible* point. Thus phosphorus, sulphur, hydrogen, carburetted hydrogen, carbon, each takes fire at successively higher heats.

COMPASS. A name given to instruments contrived to indicate the magnetic meridian, or the position of objects with respect to that meridian. According to the purposes to which the instrument is chiefly applied, it becomes the *mariner's compass*, the *azimuth compass*, the *variation compass*, each particular application requiring some peculiarity of construction; but whatever modifications it may receive, the essential parts are the same in all cases. These are a magnetized bar of steel, called the *needle*, having fitted to it at its centre a cap which is supported on an upright pivot, made sharp at the point in order to diminish the friction as much as possible, and allow the needle to turn with the slightest force. The *mariner's compass* has a circular card attached to its needle, which turns with it; and on the circumference of which are marked the degrees, and also the 32 *points* or *rhombs*, likewise divided into half and quarter points. The pivot rises from the centre of the bottom of the circular box, called the compass box, which contains the needle and its card, and which is covered with a glass top to prevent the needle from being disturbed by the agitation of the air. The compass box is suspended within a large box, by means of two concentric brass circles or gimbals, the outer one being fixed by horizontal pivots, both to the inner circle which carries the compass box, and also the outer box, the two sets of axes being at right angles to each other. By means of this arrangement the inner circle, with the compass box, needle, and card, always retain a horizontal position notwithstanding the rolling of the ship.

The principal requisites of a compass are intensity of directive force, and susceptibility. The first of these is obtained by constructing the needle of the material and form best suited to receive and retain the magnetic virtue. A number of experiments on this subject were made by Coulomb, and more recently by Captain Kater, an account of which is given in the *Phil. Trans.* for 1821. Captain Kater found that the kind of steel capable of receiving the greatest magnetic force is shear steel; and that the best form is that of a lozenge or rhomboid cut out in the middle, so as to diminish the extent of surface in proportion to the mass, it being found that the directive force of the needle, when magnetized to saturation, depends not on the extent of surface, but on the mass. Beyond a certain limit (about five inches) no additional power is gained by increasing the length of the needle; and needles exceeding a very moderate length are apt to have several consecutive poles, the effect of which is to produce a great diminution of directive force. On this account short needles, made very hard, are to be preferred.



The *azimuth compass*, being intended to show the bearing of objects in respect of the magnetic meridian, has its circle divided merely into degrees, instead of the rhombs used in navigation, and is provided with sights to allow the angles to be taken more accurately.

The *variation compass*, is designed to exhibit the diurnal changes in the deviation of the magnetic from the true meridian; and the needle is generally made of much greater length than the mariner's compass, in order to render minute variations more sensible.

Mr. Dent, of England, in 1845, made an improvement in the compass, which consists in placing the magnetic needles and the card on an axis, instead of the usual mode of suspension, the point being higher than the centre of gravity, and subject when on shipboard to the law of pendulous bodies. Mr. Dent has also so improved the azimuth compass, that by turning an azimuth 180°, it effects the correction for collimation; and by inverting the card, it being engraved on both sides, affords the means of determining the error of the zero on the card, not coinciding with the magnetic meridian.

CONCRETE. In architecture and engineering a mass composed of stone chippings or ballast cemented together through the medium of lime and sand, usually employed in making foundations where the soil is of itself too light or boggy, or otherwise insufficient for the reception of the walls. The essential quality of concrete seems to be that the materials should be of small dimensions, so that the cementing medium may act in every direction round them, and that the latter should on no account be more in quantity than is necessary for that purpose. Architects and engineers have much varied the proportions of lime and sand used. If the lime, which should be fresh and ground to powder, be good stone lime, it will bear three or four times its measure by bulk of sand. These, and the ballast or gallots, as the stone chippings are called, should be thoroughly turned over and mixed together. If the foundations be wet, the mixture will want very little, if any water; indeed, sometimes the ballast only is wetted, and then covered over with the lime and sand. It is then filled into the barrows, and run on to be dropped from a stage into the foundations. This latter operation should be performed at as great a height as possible above the level of the trench, in order that the whole of the different particles of the composition may be compressed together so as to occupy the least possible space. The stones employed should not exceed the size of a common hen's egg. The mass very quickly sets and becomes extremely hard.

COOLER. An apparatus used by brewers and distillers for cooling worts. The coolers generally consist of very shallow vessels exposing great surface, and placed in the high and airy parts of the brewery: the cooling is sometimes assisted by fans, which agitate the air over their surfaces. Worts are also occasionally cooled by causing them to traverse metal pipes, which are surrounded by a counter-current of cold water.

COP-SPINNER. A piece of machinery

for this purpose was exhibited at the fair of the American Institute, N. Y., in 1849, which appears to combine the qualities of the throstle and mule in one frame. The rovings from bobbins, at the top of the frame, are drawn through drawing rollers, like the throstle-frame; and from the drawing rollers, the thread passes at once to a small traveller, moving around a ring which surrounds the cop spindle, and the which ring has a coping motion up and down, to build the cop on the spindle, by a cam gearing below, connected by a rocking shaft to the main driving shaft. The whole of this machinery occupies no more room than the whole throstle frame; no carriage, like the mule frame, is used; the whole is compact and simple, and it does its work well. It is asserted that it will spin 100 per cent more yarn than the flyer spindle, with one half the power, compared to the quantity produced; and that 2,320 spindles produces as much yarn as 4,600 spindles on the old machines. There can be no question about the superior and safe speed with which this machine can be driven. The inventors and proprietors are Mr. John C. Dodge and Sons, Dodgeville, Attleborough, Mass.

COPAIBA or COPIVI BALSAM. An exudation from the *Copaifera officinalis*, a South American tree; it is a liquid resin, and yields by distillation a considerable quantity of a pungent volatile oil. A small teaspoonful taken twice a day in a glass of water proves diuretic, and is of use in the cure of gleet and the latter stages of *gonorrhœa*. A larger dose is aperient, and has been of service in the treatment of *hæmorrhoids*.

COPAL. A generic name applied to clear gums? This substance is often improperly called *gum copal*. It is a peculiar resin, very difficultly soluble in alcohol; hard, brittle, and inodorous; its specific gravity varies from 1·04 to 1·13. It is the produce of the *Rhus copalinum* and of the *Elæocarpus copaliferus* of the East Indies: a third kind of copal is also brought from the coast of Guinea. It is used in varnishes. It dissolves in caoutchicine diluted with alcohol.

COPPER. This metal was known at a very remote period; and in the early ages of the world, before iron was in use, copper was the chief ingredient in domestic utensils and instruments of war. It is an abundant metal, and is found native, and in many ores; of these the most important are the varieties of *pyrites*, which are sulphurets of copper and iron. There are 19 principal ores of copper, and several subvarieties. There are no rules by which copper ores may be known externally, but after fusion with nitre, water of ammona receives a deep blue tint from any cupreous ore. The ores are native copper, sulphurets, oxides, silicates, carbonates, sulphates, phosphates, clorides, and arseniates. Native copper is found abundantly on the shores of Lake Superior, both in Canada and this country, where it is found imbedded in trap, intruded through secondary rocks; perhaps this is the largest district of native copper in the world. The mass discovered by Schoolcraft on the west bank of the river Onontagon weighs 12,200 lbs. It is now at Washington. Large masses of pure copper are quarried at the several mines in that region (Minesota) to which attention was first called by Dr. Hutton.

Some of these veins contain 10 per cent of silver, which brings its value up to between four and five thousand dollars per ton. The Eagle Harbor Mining Company drifted along a piece of native copper ninety feet without finding its length and four feet downwards, without reaching its depth; its average thickness was 18 inches. The veins vary in thickness from 6 inches to 2 feet branching east and west, in small strings 2 inches thick, and 12 to 24 inches long. The trap in the interstices are charged with native copper to about 50 per cent. There are six very profitable veins in this shore. Dr. Jackson has shewn that these mines were worked by the native Indians many years back. Congress, in 1847, directed a survey of these mines to be made; the report has not yet been sent in. In the working of the Cliff and Minesota mine the difficulty has been to get away pieces small enough. Seven pieces taken from the Cliff mine in 1850 weighed 29,852 lbs., and 4 from Minesota weighed 14,641 lbs. The latter company smelt their copper in New York. The copper is chiselled away with heavy hammers.

The pyritic ores are the vitrious copper ore, which consists of 81 copper and 19 sulphur, found in the U. S. in old red sandstone. The purple copper ore contains iron with sulphur: it is not found in quantity. The grey copper ore consists of copper 52, iron 23, and 14 sulphur. It occurs plentifully in Russia, Chili, and Mexico.

Yellow copper ore is the most abundant ore, found plentifully in this northern and southern continent. It contains copper 30, iron 32, sulphur 36; lead and arsenic 3.

The red oxide, or tile ore, is the richest variety, containing 88·5 per cent of copper. It occurs in Peru and Chili. Azure copper and malachite are carbonates; they are found in Pennsylvania and Lake Superior. The finest specimens of malachite are from the Siberian Ural Chain in Russia, where it occurs so massive that large doors 30 feet by 18 have been cut out of the mineral, and are now exhibited in the Crystal Palace, London.

The ores are repeatedly roasted and fused to drive off the sulphur, and the oxide of copper is ultimately reduced by the joint agency of heat and carbon. Copper is distinguished by its color. Its specific gravity is 8·6. It is ductile and malleable, and requires a temperature equal to about 2000° of Fahrenheit's scale for its fusion; that is, nearly a white heat. Exposed to air and moisture, copper gradually becomes covered by a green rust; heated red-hot, it absorbs oxygen, and is superficially converted into a black oxide, which is the basis of the principal salts of copper; it consists of 32 copper and 8 oxygen. It forms blue or green salts with the acids; of these the *sulphate of copper*, or blue vitriol, is a good example. The salts of copper are poisonous; and in consequence of the use of copper vessels for culinary purposes, food is sometimes contaminated by them. It is detected when in very minute quantities by the bright blue color produced by the addition of liquid ammonia, and by a brown precipitate with ferrocyanate of potash. A clean plate of iron dipped into a solution containing copper becomes covered with the latter metal in a metallic state.

Two improvements in the smelting of copper ores have been suggested. One is to roast the sulphuretted copper ores with salt. The sulphur is converted into sulphuric acid, which seizes on the soda of the salt. Its chlorine passes to the copper, forming a chloride, which can be dissolved out by water. The copper is separated from this solution by pieces of iron dropped into it.

The other mode is by roasting to convert the ore into a sulphate of copper, and dissolve this in water. The copper is thrown down by iron as in the first instance. (*See* METALLURGY.)

Bronze and *Bell Metal* are alloys of copper and tin. They are melted in crucibles, and cast in charcoal moulds. An alloy of 100 copper and 4 of tin makes a good metal for medals.

Copper 100, and tin 14, affords a metal for edge tools equal in hardness to steel. *Cymbal* and *Gong Metal* consists of copper 100, and tin 25. After being heated it should be suddenly cooled.

For White Copper, *see* GERMAN SILVER.

Copper may be *tinned* by placing a sheet of tin on a well polished surface of copper, and subjecting them to a strong heat, a little resin or muriate of ammonium being sprinkled between the plates to prevent oxidation.

COPPERAS. Green vitriol, or sulphate of iron.

COPPERPLATE. In engraving, a plate of copper highly polished on which an engraving is made.

CORAL. A calcareous substance, the covering of the coral insect. It is fished up in the Mediterranean, Red, and Indian seas; mostly of a red tint, but also flesh colored, or white. It is used for making necklaces, crosses, &c., and is worked like precious stones. It is composed of carbonate of lime, with a trace of phosphate. The debris of the coral animal washed on shore, or dredged up, forms a valuable manure.

CORK. The bark of the Quercus liber, a species of oak which grows along the shores of Mediterranean Europe. It is removed from the tree by making circular incisions, and connecting these by longitudinal ones; the bark is then peeled off, wetted to flatten it between boards; it is then fire dried, which blackens the surface. When burned, it forms a light black substance, known as Spanish black. Corks are cut with the pores laterally; bungs have them downwards, hence they do not keep in the liquid as well. Cork is also used for inner soles, floats in water, models, and false limbs. Powdered cork, treated with alcohol, leaves 70 per cent of suberine; treated with nitric acid, it is changed into resin, oxalic acid and suberic acid.

CORROSIVE SUBLIMATE. The bicloride of mercury, composed of 200 mercury+72 chlorine. It is an acrid poison of great virulence: the stomach-pump and emetics are the surest preventives of its deleterious effects when accidentally swallowed; white of egg has also been found serviceable in allaying its poisonous influence upon the stomach. Its specific gravity is 5·2. It requires 20 parts of cold water, but only two of boiling water, for its solution. (*See* MERCURY.)

CORUNDUM. A crystallized or massive mineral of extreme hardness, and composed of nearly pure alumina; it is usually almost opaque, and of a reddish color. It is allied to the sapphire.

COTTON. The soft vegetable down in the seed vessels of the cotton plant (*gossypium herbaceum*), cultivated in this country, South America, the East and West Indies, and Egypt. It is an annual plant, which forms its seed in pods, which are triangular, and have each three cells; in these lie the downy cotton. The fibres of cotton are very fine, delicate, and flexible; under the microscope they are flat, triangular, and somewhat contorted; their sides are serrated, which explains the cause of their adhering together, and enables them to be spun into thread. In the southern states, three kinds are cultivated: the nankeen cotton, the green seed, and the black seed cotton. The two first are upland and short staple variety. The last has a long fine staple.

Two machines are used to clean the cotton from the seed,—the roller gin and the saw gin. The first consists of two small cylinders, between which the cotton is drawn, while the seed is prevented by its size from passing. The saw gin, invented by E. Whitney, is used for the black seed, which adhere too strongly to be separated by the rollers. His apparatus is a receiver, fitted on one side with wires an eighth of an inch apart; between these pass a number of circular saws, revolving on a common axis. The cotton is caught by the teeth of the saws, and drawn through the grating, which is too narrow to admit the seeds to pass. The cotton thus separated is swept off the saws by a revolving brush; the seeds fall out at the bottom. The cotton crop of this country in 1848 was estimated at 1,066,000,000 lbs., value $74,620,000. The following is a tabular view of the value of raw and manufactured cotton for the last five years, with the amount of export to Britain and France.

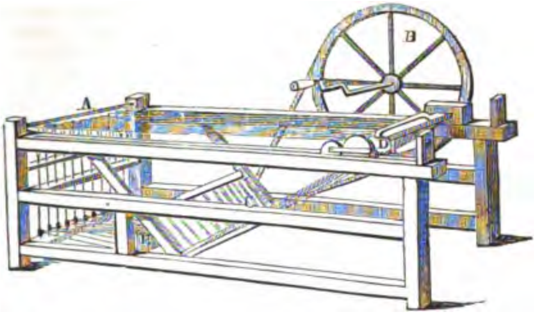
Years.	Raw Cotton.	Home Manufactured.	Exported to Great Britain.		Exported to France.	
			Raw Cotton.	Manufac. Cotton.	Cotton Wool.	Manufac. Cotton.
1846	$42,767,341	$ 8,545,481	$27,707,717	$9,607	$10,080,465	
1847	53,415,848	4,082,543	35,841,265	6,765	10,381,318	$ 216
1848	61,998,294	5,718,205	41,925,258	28	11,428,850	2,374
1849	66,396,967	5,933,129	47,444,899	2,591	10,185,713	
1850	71,984,616	4,734,424	48,884,453	50	14,395,449	589
	$296,563,066	$53,013,762	$201,803,592	$19,041	$56,471,798	$3,229

The clean cotton is now passed to the *roving machine*, the main feature of which consists of a system of vertical spindles, on each of which is placed a reel or bobbin, and also a kind of fork called a "fly," still farther removed than the bobbin from the axis of the spindle. The drawing or delicate sliver of cotton is first drawn through or between rollers, and elongated to the state of a roving; then this roving passes down a tube in one prong of the fork or fly, and becomes twisted by the revolution of the fly round the bobbin, while at the same time the twisted roving becomes wound with great regularity upon the bobbin. The machine in fact performs three different and distinct operations; it first attenuates the "drawing" to a state of still greater thinness and delicacy than it had before; it then gives to the "roving" thus produced a slight twist, sufficient to enable the fibres to cohere; and lastly, it winds this twisted roving upon a bobbin, on which it is conveniently transferred to the spinning-machine. There is a variety of the apparatus employed in this process called the "tube-roving frame," which produces a much larger quantity of roving in a given time than the "bobbin-and-fly frame;" but the roving produced is inferior, and only fitted for certain purposes.

The next operation is that of *spinning*. The twist is given to the thread by flyers driven by bands which receive their motion from a horizontal fly-wheel, or from a longitudinal cylinder. This has been called *water-twist* yarn.

The mule-jenny was invented by Crompton, of Bolton, England. This machine is so named because it is the offspring, so to speak, of two elder machines, the jenny and the water-frame. A mule is mounted with from 240 to 1000 spindles, and spins, of course, as many threads.

The following cut represents the original *jenny* of Hargreaves, by which one person was enabled to spin from 16 to 40 threads at once. The soft cords of rovings wound in double conical cops upon skewers, were placed in the in-



clined frame at C; the spindles for first twisting and then winding-on the spun yarn were set upright in steps and bushes at A, being furnished near their lower ends with whorls, and endless cords, which were driven by passing round the long-revolving drum of tin plate E. D is the clasp or clove, having a handle for lifting its upper jaw a little way, in order to allow a few inches of the soft roving to be introduced. The compound D being now pushed forward upon its friction wheels to A, was next gradually drawn backward, while the spindles were made to revolve with proper speed by the right hand of the operative turning the fly-wheel B. Whenever one *stretch* was thereby spun, the clove frame was slid home towards A; the spindles being simultaneously whirled slowly to take up the yarn, which was laid on in a conical cop by the due depression of the faller wire at A with the spinner's left hand.

The yarn being now spun into either fine or coarse thread, is applicable for the warp or weft in woven goods; when the weaving is done at home, it is by hand-loom; when in a factory, it is by power-loom. This process will be followed under WEAVING and TEXTURE FABRICS.

The following tables, extracted from an article on Cotton, written by Mr. Dodge for the *Scientific American*, are inserted here, as they present some valuable results.

A Table showing the number of Spindles run, and the annual increase of work in U. S.

Years.	No. of spindles.	No. of yards manufactured.	Increase of No. of spindles.	Increase of No. of yards.
1838	1,422,000	469,200,000	185,000	51,000,000
1839	1,520,000	501,500,000	98,000	32,300,000
1840	1,530,000	504,900,000	10,000	3,400,000
1841	1,375,000	453,900,000	decreas.	decrease
1842	1,674,000	552,500,000	*97,000	*32,300,000
1843	1,788,000	589,900,000	114,000	37,400,000
1844	2,004,000	661,300,000	216,000	71,400,000
1845	2,174,000	717,400,000	170,000	56,100,000
1846	2,267,000	748,000,000	93,000	30,600,000
1847	2,576,000	850,000,000	309,000	102,000,000
1848	2,800,000	918,000,000	224,000	68,000,000

* Gain after deducting what 1841 lost.

Total No. of spindles in eleven years, 1,130,000; total No. of yards manufactured, 6,966,600,000; total increase of spindles, 1,516,000; total increase of No. of yards manufactured, 484,500,000.

Average per year—No. of spindles, 21,920,909; No. of yards manufactured, 633,327,272; increase of spindles, 187,818; increase of No. of yards manufactured, 44,045,454.

A Table showing the number of Operatives employed by the principal cotton manufacturing establishments in the United States, together with the annual and aggregate amount of wages paid the same from 1838 *to* 1848, *inclusive.*

Years.	Males.	Females.	Wages of Females.	Wages of Males.	Aggregate.
1838	14,000	47,000	9,287,200	4,368,000	13,655,200
1839	15,000	50,000	9,880,000	4,680,000	14,560,000
1840	15,500	52,000	10,275,200	4,836,000	15,111,200
1841	13,800	46,000	9,089,600	4,305,000	13,395,200
1842	16,500	55,000	10,868,000	5,148,000	16,016,000
1843	17,000	59,000	11,658,400	4,304,000	16,962,400
1844	20,000	66,000	13,041,600	6,240,000	19,281,600
1845	22,000	72,000	11,227,200	6,864,000	21,091,200
1846	23,000	75,000	14,820,000	7,176,000	21,996,000
1847	25,000	85,000	16,796,000	7,800,000	24,596,000
1848	27,000	95,000	18,772,000	8,424,000	27,196,000

Total aggregate of males employed in eleven years, 208,800; females, 702,000. Total aggregate wages paid to females for eleven years, $138,715,200; males, $65,145,600. Total, $203,860,800.

Average No. of males employed per year, for eleven years, 18,982; females, 63,818. Average aggregate paid females per year for eleven years, $12,610,472; males, $5,922,327. Total, $18,532,800.

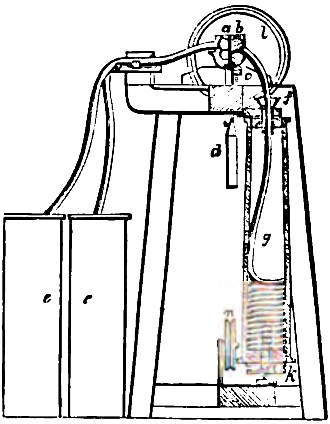
The chief manufactures of cotton are carried on in the New England States: it is only of late years that manufactures have sprung up in the South; at the present time in Georgia, there are 40 cotton mills working 60,000 spindles, and using 45,000 bales of cotton per annum. In Tennessee there are 80 factories, running 30,000 spindles and 700 looms, and using 15,000 bales. In Alabama there are 12 factories, working 15,580 spindles and 300 looms, and consuming 5,000 bales of raw cotton.

COTTON MANUFACTURE. After the cotton has been ginned (see previous article), and picked and batted, that is, beat up and separated in a light uniform mass, the first operation is that of *carding*, which serves to equalize the substance of the cotton, and dispose the fibres in a parallel direction. The carding engine consists of a revolving cylinder covered with cards, which is nearly surrounded by a fixed concave framing also lined with cards, with which the cylinder comes in contact. From the cylinder, called the breaker, the cotton is taken off by the motion of a transverse comb, called the *doffing plate*, and passes through a *second carding* in the finishing cylinder.

The cotton leaves the carding-engine in the state of a delicate, flat, narrow strip or ribbon, called a *sliver*; and these slivers have now to be converted into *drawings*, by being elongated, narrowed, and thinned to a still more delicate condition. This process is one to which Arkwright paid particular attention, as having an important influence on the quality of spun cotton. In the first place the slivers are collected in tall cans, generally either four or six in number, on one side of the drawing frame, and are from thence carried upwards to two pairs of rollers, the two rollers of each pair revolving in contact. Here all the slivers or cardings are collected into one group, and are drawn between the rollers by the rotation of the latter. Now if these rollers all revolved equally fast, the cotton would leave them with the same united thickness as when it entered; but the last pair revolves quicker than the first, so as to draw out the cotton in a more attenuated ribbon; because the more slowly-revolving rollers do not supply the material fast enough for the maintenance of the original thickness. This is perhaps the most important principle in the whole range of the cotton manufacture; for it is exhibited alike in the present process and in the next two which follow. All the four or six slivers are connected into one before being caught between the rollers; and after leaving the rollers, the united "drawing" passes through a kind of trumpet-shaped funnel, and is thence conducted into a tall can, round the interior of which it coils itself. One consequence of the drawing process, if properly conducted, is, that the drawing is perfectly equal in thickness in every part, and formed of parallel fibres; and in order to insure this, the drawing is repeated more than once, each narrow ribbon being "doubled" with others before each successive drawing.

The preliminary spinning process is called *roving*. At first the torsion is slight in proportion to the extension, since the solidity of the still coarse sliver needs that cohesive aid only in a small degree, and looseness of texture must be maintained to facilitate to the utmost the further elongation.

Fig. 33, is a section of the can roving frame, the ingenious invention of Arkwright, which, till within these 14 years, was the principal machine for communicating the incipient torsion to the spongy cord furnished by the drawing heads. It differs from that frame in nothing but



the twisting mechanism; and consists of two pairs of drawing rollers, *a* and *b*, between which the sliver is extended in the usual way; *c* are brushes for cleaning the rollers; and *d* is the weight which presses the upper set upon the lower. The wiping covers (not shown here) rest upon *a b*. The surface speed of the posterior or second pair of rollers is 3, 4, or 5 times greater than that of the front or receiving pair, according to the desired degree of attenuation. Two drawn slivers were generally united into one by this machine, as is shown in the figure, where they are seen coming from the two cans *e e*, to be brought together by the pressure rollers, before they reach the drawing rollers *a b*. The sliver, as it escapes from these rollers, is conducted into the revolving conical lantern *g*, through the funnel *f* at its top. This lantern-can receives its motion by means of a cord passing over a pulley *k*, placed a little way above the step on which it turns. The motion is steadied by the collet of the funnel *f*, being embraced by a brass busk. Such a machine generally contained four drawing heads, each mounted with two lanterns; in whose side there was a door for taking out the conical coil of roving.

The bobbin and fly frame is now the great roving machine for fine spinning. This is so complicated a machine that it is not possible to give here a detailed description of it. It has gone through several improvements and is continually altering in detail.

COURT PLASTER. To make this, black silk is strained and brushed over ten or twelve times with the following preparation: — Dissolve ½ an ounce of balsam of benzoin in 6 ounces of rectified spirits of wine; and in a separate vessel dissolve 1 ounce of isinglass in as little water as may be. Strain each solution, mix them, and let the mixture rest, so that any undissolved parts may subside; when the clear liquid is cold it will form a jelly, which must be warmed before it is applied to the silk. When the silk coated with it is quite dry, it must be finished off with a coat of a solution of 4 ounces of Chian turpentine in 6 ounces of tincture of benzoin, to prevent its cracking.

CRANE. In Mechanics, a machine for raising heavy weights, and depositing them at some distance from their original place; for example, raising bales from the hold of a ship, and depositing them on the quay. A jib or transverse beam, inclined to the vertical in an angle of 40° or 50°, is constructed, which, by means of a collar, turns on a vertical arbor. The upper end of the jib carries a fixed pulley, and the lower end a cylinder, which is put in motion by a wheel and pinion, or cog wheel, or merely with a handle. The weight is made fast to a rope which passes over the pulley and is wound round the cylinder. On turning the cylinder, the weight is raised as far as necessary; the jib is then turned on its arbor till the weight is brought immediately over the spot where it is to be deposited; when, by withdrawing the moving power, it is allowed to descend by its own gravity. Cranes may be constructed of immense power. They are generally turned by human force; sometimes, however, by a steam engine.

CRANK. A mechanical contrivance for changing a revolving into an alternate motion. An iron axis is bent in some part of its length out of its rectilinear direction. As the axis turns, the bent part describes the circumference of a circle, and gives a reciprocating motion to a piston rod attached to it.

CRANK. In Nautical language, a ship is said to be *crank*, when by the form of its construction, or by want of a sufficient quantity of ballast or cargo, or by being loaded too much above, it is incapable of carrying sail without being exposed to the danger of oversetting.

CRAPE. A species of gauze made of raw silk woven without crossing. It is stiffened with gum-water.

CRAYONS. Colored cylinders used for drawing upon paper; they are usually made of a fine pipe-clay, colored with metallic pigments or carmine. Crayons containing plumbago are styled *solid lead pencils*.

General Lomet proposes the following composition for red crayons: He takes the softest hematite, grinds it upon a porphyry slab, and then carefully elutriates it. He makes it into a plastic paste with gum arabic and a little white soap, which he forms by moulding, as above, through a syringe, and drying, into crayons. The proportions of the ingredients require to be carefully studied.

CRAYONS, LITHOGRAPHIC. Various formulæ have been given for the formation of these crayons. One of these prescribes, white wax 4 parts; hard tallow soap, shellac, of each 2 parts; lamp black 1 part. Another is, dried tallow soap and white wax, each 6 parts; lamp black 1 part. This mixture being fused with a gentle heat, is to be cast into moulds for forming crayons of a proper size.

CREAM. A semifluid yellowish substance which collects on the surface of milk, and which is made into butter by the process of churning. When the milk of any animal is allowed to stand for some time, it spontaneously undergoes certain changes; this substance rises to the surface and forms a thin stratum, which is called cream, and which consists chiefly of oily particles; while the milk below, which of course is thinner than it was before the cream separated from it, is of a pale, blueish color, and consists of curd, coagulum, or the matter of which cheese is made. When cream is kept for some days it gradually becomes thicker, and partially coagulated; and if put into a linen bag, and suspended from the ceiling of a cool room, it will acquire the consistence of cheese; and this is one among other modes of making cream cheeses. When cream is shaken by churning, it is resolved into its component parts, and hence we have butter and buttermilk. In order to make butter it is not always necessary that the cream should be separated from the milk; but whether separated or not, the process is facilitated by allowing the liquid to stand for some time, during which a part of the sugar contained in the serum is changed into an acid, which shortens the process of churning by facilitating the separation of the butter from the milk. When either cream or milk is churned without having previously become sour, the process is much more tedious; and sometimes, from causes not easily accounted for by the dairy-maid, it is unsuccessful, and the milk is said to be bewitched. The true cause, however, is the want of acidity; because it has been found that the addition of a small portion of vinegar will dissolve the charm, and cause the almost immediate appearance of butter. Cream, when separated from milk, and kept till it has become acid, is frequently mixed with milk newly drawn from the cow; and this eaten with sugar is one of the most delicious preparations of the dairy. Common clotted cream is simply milk and cream in a coagulated state, and sour. When the clotted cream is broken and stirred, and the whey drawn off, the mass may be turned into cheese by artificial pressure, by which the whey is separated instantaneously; or by suspending it in a porous bag, in a cool airy situation, when it will be separated by degrees.

CREOSOTE or KREASOTE. A colorless, transparent, oily liquid, separable from wood-tar and pyroligneous acid, by repeated distillation and rectification; it appears to be the principle to which the antiseptic power of wood-tar, smoke, and crude pyroligneous acid is owing.

Creosote dissolves several salts, particularly the acetates, and the chlorides of calcium and tin; it reduces nitrate and acetate of silver. It also dissolves indigo blue; a remarkable circumstance. Its action upon animal matters is very interesting. It coagulates albumen, and prevents the putrefaction of butchers' meat and fish. For this purpose these substances must be steeped a quarter of an hour in a weak watery solution of creosote, then drained and hung up in the air to dry. Hence Riechenbach has inferred that it is owing to the presence of creosote that meat is cured by smoking; but he is not correct in ascribing the effect to the mere coagulation of the albumen, since *fibrine* alone, without creosote, will putrefy in the course of 24 hours, during the heat of summer. It kills plants and small animals. It preserves flour paste unchanged for a long time.

Creosote exists in the tar of beechwood, to the amount of from 20 to 25 per cent., and in crude pyroligneous acid, to that of 1¼.

It ought to be kept in well-stoppered bottles, because when left open it becomes progressively yellow, brown, and thick.

CROTON AQUEDUCT. This beautiful structure has been built after the plan of the Roman buildings—that is, in channels of masonry, rather than in metal pipes. The following account is abridged from Tower's work on the Croton Aqueduct:

Dr. Brown, in 1798, first called attention to the necessity of a good supply of water for the city of New-York. In the next year the Manhattan Company sank wells of great depth. In 1834, an act passed the Legislature, authorizing five Water Commissioners to examine and consider all matters relative to a supply of water to the city. These Commissioners decided in favor of using the Croton River, and bringing it in a closed aqueduct of masonry, at an estimate of $5,412,336 72. The work was commenced in May, 1837, and the 22d June, 1842, the aqueduct received the water from the fountain reservoir on the Croton; on the 27th it entered the receiving reservoir in the city, and on 4th July it was admitted into the distributing reservoir. The sources of the Croton River are in Putnam county, 50 miles from New-York; they are about twenty lakes or ponds, occupying about 3,800 acres. The water is so remarkably clear and pure, that the native Indians called it clear water. The dam on the Croton River is thirty-eight feet above the original level of the water-flow, and sets the water back about six miles, forming the *fountain reservoir*, which contains an area of 400 acres. This large reservoir allows the water to settle before entering the aqueduct, and it has an available capacity of 600,000,000 gallons; this has been looked on as sufficient store for one-third of a million of people for ninety days, a longer period than any drought would last. The minimum flow of water in the river where the aqueduct begins, is 27,000,000 gallons in twenty-four hours. The aqueduct itself is calculated to convey 60,000,000 gallons in that time. From the fountain reservoir to the receiving reservoir is thirty-eight miles, the aqueduct for which is of stone, except where the Haarlem River is crossed over, and in passing a deep valley in the island, where iron pipes are used. These pipes descend and rise again, so that they are always full. The surface of the reservoir is 166¼ feet above the level of the tide at New-York; that of the receiving reservoir is 119 feet, so that the fall of the river during its course through the 38 miles of aqueduct, is 47¼ feet. From the receiving reservoir it is carried in iron pipes (two miles) to the distributing reservoir, where the surface of the water is 115 feet above the tide level.

At suitable places on the line of aqueduct six waste weirs are constructed, to discharge surplus water in such a mode, that when the water reaches a certain level, it flows off at the side.

For ventilation, hollow cylinders of stone are erected over the aqueduct, and rise 14 feet above the surface of the ground. These occur at every mile, and at every third mile there is one having a door to allow of entrance into the aqueduct; these have a diameter of four feet, the former only of two; the top is covered by an iron grating. Besides these there are places marked at every quarter of a mile of the course, where opening can be made readily in cases of emergency. Where streams intersect the line of aqueduct, culverts are built to allow them to pass under. At each end of the aqueduct are *gate chambers*, with two sets of gates, the *regulating* and the *guard* gates: the former of gun metal, the latter of cast iron.

The height of the interior of the aqueduct is 8 feet 5¼ inches, and the greatest width 7 feet 5 inches. The velocity of the water is 1¼ miles per hour when the water is two feet deep. The average depth is probably four feet.

The foundations of the channel were formed with cement, the side walls of stone, and the bottom and inside faced with brick; the top also covered with an arch of brick. In tunnel-cutting, the natural rock in some places served as roof.

The bridge which crosses the Haarlem River is the most interesting work on the line; its width is 21 feet, and it is 150 feet from the top of the work to the foundations in the river. The iron pipe conveying the water along this is 3 feet in diameter. In passing through the Manhattan valley two pipes are used, each 3 feet in diameter; provision, however, has been made for four such.

The capacity of the receiving reservoir is 150,000,000 gallons when full. It is divided into two unequal parts, with a connecting pipe to allow of an equalizing of the level. The distributing reservoir is two miles lower down the island, and three miles from City Hall; the water in it is 36 feet deep, and it is calculated to hold 20,000,000 gallons. It is 40¼ miles distant from the fountain reservoir.

The whole of the cost of the work, exclusive of the pipes in the city below the distributing reservoir, is about $9,000,000. It is a beautiful work of art,—a worthy rival of the finest of the Roman aqueducts. The success of this undertaking in New-York has stimulated other Atlantic cities to supply themselves with abundance of pure water in a similar manner and the aqueduct which supplies Boston from the Cochituate pond is highly creditable.

CRUCIBLES are small conical vessels, narrower at the bottom than the mouth, for reducing ores in docimacy by the dry analysis, for fusing mixtures of earthy and other substances, for melting metals, and compounding metallic alloys. They ought to be refractory in the strongest heats, not readily acted upon by the substances ignited in them, not porous to liquids, and capable of bearing considerable alternations of temperature without cracking; on which account they should not be made too thick. The best crucibles are formed from a pure fire-clay, mixed with finely ground *cement* of old crucibles, and a portion of black lead or graphite. Some pounded coke may be mixed with the plumbago. The clay should be prepared in a similar way as for making pottery-ware; the vessels after being formed must be slowly dried, and then properly baked in the kiln. Crucibles formed of a mixture of 8 parts in bulk of Stourbridge clay and cement, 5 of coke, and 4 of graphite, have been found to stand 23 meltings of 76 pounds of iron each, in the Royal Berlin foundry. Such crucibles resisted the greatest possible heat that could be produced, in which even wrought iron was melted, equal to 150° or 155° Wedgewood, and bore sudden cooling without cracking. Another composition for brass-founding crucibles is the following: ¼ Stourbridge clay, ¼ burned clay cement, ¼ coke powder, ¼ pipe clay. The pasty mass must be compressed in moulds. The Hessian crucibles of Germany are made from a fire-clay which contains a little iron, but no lime; it is incorporated with silicious sand. The dough is compressed in a mould, dried, and strongly kilned. They stand saline and leaden fluxes in docimastic operations very well; are rather porous on account of the coarseness of the sand, but are thereby less apt to crack from sudden heating or cooling. They melt under the fusing point of bar iron. Beaufay in Paris has lately succeeded in making a tolerable imitation of the Hessian crucibles with a fire-clay found near Namur in the Ardennes.

Berthier has published the following elaborate analysis of several kinds of crucibles:

	Hessian.	Beaufay.	English for Cast Steel.	St. Etienne for Cast Steel.	Glass Pots at Nemours.	Bohemian Glass Pots.	Glass Pots of Creusot.
Silica, - - - -	70·9	64·6	63·7	65·2	67·4	68·0	68·0
Alumina, - - -	24·8	84·4	20·7	25·0	82·0	29·0	28·0
Oxide of Iron, -	3·8	1·0	4·0	7·2	0·8	2·2	2·0
Magnesia, - -	trace	—	—	trace	trace	0·5	trace
Water, - - -	—	—	10·3	—	—	—	1·0

Wurzer states the composition of the sand and clay in the Hessian crucibles as follows:

Clay—silica 10·1, alumina 65·4, oxides of iron and manganese 1·2, lime 0·3, water 23.

Sand—silica 95·6, alumina 2·1, oxides of iron and manganese 1·5, lime 0·8.

Black lead crucibles are made of two parts of graphite and one of fire-clay, mixed with water into a paste, pressed in moulds, and well dried, but not baked hard in the kiln. They bear a higher heat than the Hessian crucibles, as well as sudden changes of temperature, have a smooth surface, and are, therefore, preferred by the melters of gold and silver. This compound forms excellent small or portable furnaces.

CUDBEAR, OR PERSIO, is a powder of a violet red color, difficult to moisten with water, and of a peculiar but not disagreeable odor. It is partially soluble in boiling water, becomes red with acids, and violet blue with alkalies. It is prepared in the same way as archil, only towards the end the substance is dried in the air, and is then ground to a fine powder, taking care to avoid decomposition, which renders it glutinous. In Scotland they use the lichen tartareus, more rarely the lichen calcareus, and omphalodes, most of which lichens are imported from Sweden and Norway, under the name of rock moss. The lichen is suffered to ferment for a month, and is then stirred about to allow any stones which may be present to fall to the bottom. The red mass is next poured into a flat vessel, and left to evaporate till its urinous smell has disappeared, and till it has assumed an agreeable color verging upon violet. It is then ground to fine powder. During the fermentation of the lichen, it is watered with stale urine, or with an equivalent ammoniacal liquor of any kind, as in making archil.

CUPELLATION is a mode of analyzing gold, silver, palladium, copper, and platinum, by adding to small portions of alloys, containing these metals, a bit of lead, fusing the mixture in a little *cup* of bone earth called a *cupel*, then by the joint action of heat and air, oxidizing the copper, tin, &c., present in the precious metals. The oxides thus produced are dissolved and carried down into the porous *cupel* in a liquid state, by the vitrified oxide of lead. (*See* ASSAY, GOLD, and SILVER.)

CURRYING is the art of dressing cow-hides, calf-skins, seal-skins, &c., principally for shoes: and this is done either upon the flesh or the grain. In dressing leather for shoes upon the flesh, the first operation is to soak the leather in water until it is quite wetted, then the flesh side is shaved on a beam about seven or eight inches broad, with a knife of peculiar construction, to a proper substance, according to the custom of the country and the uses to which it is destined. This is one of the most curious and laborious steps of the whole process. The knife used is of a rectangular form, with two handles, one at each end, and a double edge. It is thrown into water again, and scoured on a board or stone commonly set apart for that use. Scouring is done by rubbing the grain or hair side with pumice-stone, or with some other stone of a good grit. These stones force out of the leather a white substance called the *bloom*, produced by the oak bark in tanning. The hide or skin is then conveyed to the shade or drying-place, where the oily substances are applied termed *stuffing*, or *dubbing;* when it is thoroughly dry, an instrument, with teeth on the under side, called a graining-board, is first applied to the fresh side, which is called *graining*,—then to the grain side, called bruising. The whole of this operation is to soften the leather to which it is applied. Whitening or paring succeeds, which is performed with a fine edge to the knife already described, and used in taking off the grease from the flesh. It is then boarded up or grained again, by applying the graining-board first to the grain, and then to the flesh. It is then fit for waxing, which is now performed by *coloring*, which is done by rubbing with a brush, dipped in a composition of oil and lamp-black, on the flesh, until it be thoroughly black. It is then sized, called *black-sizing*, with a brush or sponge, dried and tallowed; and when dry, this sort of leather called *waxed*, or black on the flesh, is curried. The currying leather on the hair or grain side, called *black on the grain*, is the same as currying on the flesh until we come to the operation of scouring it. Then the first black is applied to it while wet, which black is a solution of sulphate of iron or copperas, in plain water, or in the water in which the skins as they come from the tanner have been soaked. This is first put upon the grain after it has been rubbed with a stone; then rubbed over with a brush dipped in stale urine: the skin is then stuffed, and when dry, it is seasoned—that is, rubbed over with a brush, dipped in copperas water, on the grain till it is perfectly black. After this, the grain is raised with a fine graining-board: when it is thoroughly dry it is whitened, bruised again, and grained in two or three different ways, and when oiled upon the grain with a mixture of oil and tallow it is finished.

CURRY POWDER. (*See* TURMERIC.)

CUTLERY, in the general sense, comprises all *edged tools;* but it is now more particularly confined to the manufacture of knives and forks, scissors, pen-knives, razors, and swords. Those articles which do not require a fine polish, are made from blistered steel; while those which require the edge to possess great tenacity at the same time that hardness is not required, are made from sheer steel. The finer kinds of cutlery are made from steel which has been in a state of fusion, termed *cast steel;* no other kind being susceptible of a high polish—(*see* STEEL.) It can then be made so as to be welded to iron with great ease. Table-knives are mostly made of sheer steel. The blade is first rudely formed and cut off. It is next welded to a rod of iron about half an inch square, so as to leave as little of the iron part of the blade exposed as possible: of the iron attached to the blade enough is then taken off from the rod to form the bolster or shoulder and the tang. To give the bolster size, shape, and neatness, it is introduced into a die and a swage placed upon it: the swage has a few small blows given to it by the striker. The die and swage are called *prints*. The blade is now heated, and the proper anvil finish is given to it: this is termed smithing. It is again heated red-hot, and plunged down into cold water. It thus becomes hardened and requires to be tempered down to a blue color, when it is ready for the grinder.

Forks are a different branch of manufacture; they are made of small rods of steel, drawn out flat at one end to about the length of the prongs. The shank and tang are heated, and the form given by a die and swage. The prongs are then formed at one blow by a stamp, which weighs about 100 lbs., and falls from a height of 7 or 8 feet upon the heated end of the rod: a fly-press removes the metal left between the prongs. The forks are then annealed, which softens and prepares them for filing. The inside is then filed; they are then bent into form and hardened, by heating and plunging them into cold water. The tempering is done by exposure to the degree of heat at which grease inflames.

Almost all razors are made of cast steel, the quality of which should be very good, the razor's edge requiring great hardness and tenacity. The tempering is usually performed by placing them on the open fire, in a sand bath, or an oil bath, or a bath of fusible metal of 8 parts of bismuth, 5 parts of lead, and 3 of tin heated up to 500° Fahr. Razors are ground crosswise, upon stones from 4 to 7 inches in diameter; a small stone being needful to make the sides concave: they are then smoothed and polished.

Pen-knives have three stages in their manufacture: 1st, the forging of the blades, the spring, and iron scales; the 2d, the grinding and polishing of the blades; and 3d, the handling, or fitting up of all the parts.

The finest kind of cast steel is used in the manufacture of ladies' scissors; the larger scissors have a blade of iron, with steel edge.

The various processes of grinding and polishing are performed by machinery, moving in general by the power of steam, or a water-wheel. The grinding and polishing of cutlery is the most ruinous occupation to health and life at which any man can be occupied: few who commence to work at it early in life, reach forty years of age.

The manufacture of *handles* is carried on often in the same establishment with the steel work. According to the technical phraseology applied, all handles are called *hafts* in which a tang of the knife passes into a hole in the handle, and is there fixed; while the handles which are formed of two flat pieces riveted to a central plate, as in pen-knives, are called *scales*.

The workmen who engage in this employment confine themselves each pretty nearly to one kind of material. The pearl-handle makers procure the shells from the shores of India and Africa; these shells are about six inches in diameter, and are so extremely hard that they have to be wetted while being cut with a saw, to prevent the saw from being softened by the heat. This is a dirty occupation, and is accompanied by a "very ancient and fish-like smell," elicited by the heat from the shell itself. The pearl, or rather mother-of-pearl, is cut up into thin slices, to be afterwards used for the scales for pen-knives, razors, &c. *Ivory* handles are made by sawing up elephants' tusks into the most useful pieces they can make, by means of a circular saw. If the ivory is for scales, it is cut into veneers: but if for hafts, it is cut into small oblong pieces, which are afterwards brought to shape by hand, polished, and pierced for the reception of the tang. *Bone* handles are similarly made by cutting with a small circular saw, and then filing into shape; and the same may be said of *ebony* and fancy wood handles generally. *Saw-handles* are cut out of wood, which, after being planed to the proper thickness, is fixed in a vice, cut with a very fine saw, smoothed with files and glass-paper, pierced with rivet-holes, and riveted to the saws. *Metal* handles are of course made in a way similar to other articles of metal.

Horn handles have a peculiarity in their mode of manufacture, which places them in a distinct rank. When horn is made hot, it becomes so soft and ductile that it may be pressed into moulds; and this circumstance is taken advantage of to give an ornamental device to horn handles, except *stag's horn*, which is left in its natural state. The tips or solid parts of the ox-horn and buffalo-horn are made into hafts, while the other parts are made into scales. The mould for pressing is in two halves, which close together like a pair of pincers; and this mould has the device on each of its halves. The mould is heated in a fire; the piece of horn is cut nearly to the requisite size, and put into it; and the mould is pressed in a powerful vice, whereby the horn receives the impress of the device.

There is also a good deal of skill shown in staining horn, bone, and ivory, or in bleaching them; as also in studding and ornamenting them in various ways.

CYANIDE OF POTASSIUM. This salt, so much used now in the electrotype processes, is prepared, according to Liebig's formula, by mixing 8 parts of pounded prussiate of potash, sharply dried, with 3 parts of pure carbonate of potash, fusing the mixture in an iron crucible, by a moderate red heat, and keeping it so, till the glass or iron rod with which the fluid mass should be occasionally stirred, comes out covered with a white crust. The crucible is then to be removed from the fire; and after the disengaged iron has fallen to the bottom, the supernatant fluid, still obscurely red hot, is to be poured off upon a clean surface of iron or platinum. After concretion and cooling, the white saline mass is to be pounded while hot, and then kept in a well-stopped bottle. It consists of about 5 parts of cyanide of potassium, and 1 of cyanate of potash. For most purposes, and the analysis of ores, the latter ingredient is in no ways detrimental.

CYANITE. A massive and crystallized mineral. It has a pearly lustre, is translucent, and of various shades of blue: it is a silicate of alumina, with a trace of oxide of iron. Only found in primitive rocks.

CYANOGEN. An essential ingredient of Prussian blue. Cyanogen is a gas of a strong and peculiar odor, resembling that of rubbed peach leaves; it is obtained by heating *cyanuret of mercury*. Under a pressure of between three and four atmospheres it becomes a limpid liquid. It extinguishes a taper, is highly poisonous and unrespirable, and burns in contact of air with a rich purple flame. Water absorbs between 4 and 5 times its volume of the gas. It is composed of carbon and nitrogen in the proportions of 12 carbon+14 nitrogen=26 cyanogen; it is therefore a bicarburet of nitrogen. Mixed with oxygen it explodes by the electric spark, and is resolved into carbonic acid and nitrogen gas. It combines with hydrogen to produce the *hydrocyanic* or prussic acid: it forms with the metals *cyanurets* or *cyanides*.

CYANOMETER. An instrument contrived by Saussure for determining the deepness of the tint of the atmosphere. A circular band of thick paper or pasteboard is divided into 51 parts, each of which is painted with a different shade of blue, decreasing gradually from the deepest blue formed by a mixture of black, to the lightest formed by a mixture of white. The colored zone is held in the hand of the observer, who notices the particular tint which corresponds to the color of the sky. The number of this tint, reckoned from the lightest shade, marks the intensity at the time of observation.

DAGUERREOTYPE. The art of impressing distinct and permanent images on polished metallic surfaces. It received its name from M. Daguerre, who discovered the mode in 1839, and from whom the French government bought the right to the discovery by giving him an annuity of 10,000 francs. Compared with the present processes his views were very meagre and incomplete. The views taken were of landscapes, and the process in his hands consisted in coating the silver plate with iodine to a gold color, exposing in the camera for ten minutes in full sunlight, then exposing the plate to the fumes of mercury, and washing in hyposulphate of soda. Dr. Draper (now of New York) made the plate more sensitive by exposing it to chlorine gas after it had received the iodine coating. Views could thus be taken in shade, and in a shorter time; the impression also was more distinct. Chloride of iodine was soon after substituted for chlorine and iodine separately; and, still later, bromide of iodine was tried with much greater success.

At the present time the art is practised with wonderful delicacy of manipulation, and perfection in result, in this country. It is acknowledged that American daguerreotypes excel European in beauty of finish, with mellowness and depth of tint. Those taken in France are much better than English ones, which is no doubt due to the clearer and less cloudy skies of France. Perhaps it may be the same reason which causes to be produced better portraits in America than in western Europe.

The plate which receives the image is copper coated with silver, either by the ordinary process of plating, or by the electrotype method: the latter is preferable. The first step in the process is the cleansing the plate. Too much attention cannot be devoted to this, as upon it depends subsequent success. It is impossible to take a picture on a dirty plate. The slightest trace of oxide, sulphuret, or even film of air adhering to the plate, is sufficient to prevent the appearance of an image. Various plans of cleaning plates are practised. Some use rotten stone and water, made acid by nitric acid; others use alcohol and ammonia water. These are rubbed on to the plate with small pieces of Canton flannel. The rotten stone should be very fine, and the acid very dilute, else the plate will be streaked. It should be cleaned in the centre first, and then the edges wiped off. The acid may be removed from the plate, by washing with alcohol, or weak solution of potass; washing with a solution of hydriodate of potass increases the sensitiveness. After being cleaned the plates are *buffed*, or rubbed with a pad covered with cotton, velvet, or buckskin leather. Great delicacy is employed in the application of the buff, which should remove all traces of the materials used for polishing, and give the final purity to the plate. The plate is now ready to receive the *coating*, or films of iodine and bromine. Small boxes hold the ingredients in a glass saucer at the bottom, and the plates are placed on the sliding frame above, and passed over the surface of the saucers until they receive the due quantity of these ingredients. This quantity varies with the nature of the light and desired appearance of the picture. The depth of the coating is known by the color of the plate, which is first *straw yellow*, then orange, then *rose* color, violet, steel blue, indigo, and green. If the coating be continued beyond this, it passes into yellow again, and through the same range of colors. The iodine in the box should be quite dry, as the slightest damp on the plate mars the coating. The bromine is used as bromide of lime, made by mixing bromine with fresh slaked lime, till the whole is of an orange tint. As a rule, a good picture will be produced by coating with iodine to a dark orange yellow, then with the bromide of lime coat to a deep rose red, coat again with iodine one-tenth as long as at first coating. The plate now coated is very sensitive, the least exposure to light decomposing its surface. Hence it is necessary to shut the plate up in the tablet immediately: this is a close case with a a sliding lid. It is introduced into the camera, and the lid raised when we wish it to receive an image. The selection of a good camera is a *sine qua non* with the daguerreotype artist. Generally those of Voigtlander of Germany have the best lenses, and are to be preferred. Daguerreotypists, however, in this country prefer the American cameras. For taking views, the camera invented by Mr. Harrison is by far the best yet made for such purposes. It has been found advantageous to blacken the inside of the camera, which absorbs the rays falling on the sides, and thus prevents their reflection and interference with the rays falling upon the plate. A room lighted from above is more suitable than a window or side light, the latter producing the shadows too deeply marked. A northern aspect is preferred, as the light is more uniform through the day, although light from the south has a greater chemical influence. The sitter should not be placed too near the window, nor in front of it. The time of exposure in the camera varies with the light, amount of coating, and time of the day, from 10 seconds to 1¼ minutes. The operator's judgment is the best guide. The plate is now removed from the camera in the closed tablet, and has to be exposed to the vapor of mercury, in order to bring out the image, for as yet no trace of any delineation is visible. The mercury bath is an iron vessel of an inverted conical form, the mercury occupying the lower part: is heated with a spirit lamp until it reaches the temperature of 90 centigrade, when the plate is now placed on the frame attached to the upper part of the bath, where it receives the vapor of the quicksilver. A little window at the side allows the operator to observe the advancement of the process. The image gradually is developed as the mercurial vapor coats the plate, and when the greatest distinctness is produced (which is generally after two minutes), the plate is removed. As far as the image is concerned, nothing more is necessary to be done.

The picture is made, and has now to be preserved. It is necessary first to remove the superfluous iodine and bromine from the sides of the picture, where the light has not produced any chemical action; this is accomplished by washing with hyposulphate of soda, a salt which is capable of dissolving the iodide of silver formed on the plate. The washing should be performed immediately after the exposure to the mercury. The plate is held by a pliers in the hand, and the hyposulphate solution is poured over the plate, and washed around it. The plate is then rinsed with water, and dried off by the heat of a spirit lamp applied underneath. The hyposulphate solution should be weak.

The picture is now formed, and the superfluous coating removed: it has yet to be *fixed*. This is accomplished by gilding, or applying a weak solution of chloride of gold, washed over the plate. This protects it from any further action of light, rendering the image permanent. The solution of the chloride of gold is poured on the plate, heated beneath by the lamp, and allowed to remain on as long as any small bubbles continue to appear.

The pictures are usually colored by means of mineral powders, laid on dry with a brush. Yellow ochre burned is the usual flesh color, mixed with carmine or chrome yellow. Oxide of bismuth forms the white; Prussian blue, the blue; and the green is formed by the mixture of blue and yellow.

When the silver plate is coated, an iodide of silver is produced. When it is further exposed to bromine, a portion of bromide of silver is also formed, so that the plate is then covered with two preparations of silver, the bromide and the iodide; the latter is the salt which it is desirable to have formed upon the plate, and all applications have for their object the ready formation and decomposition of it. When exposed to the light the iodide of silver is decomposed in some places, while in other places the decomposition is not effected. When the plate already acted on by light is exposed to the mercury, the latter coats these places where the light has acted on so that the light parts of the picture are an amalgam of mercury while the dark places are of silver; the intermediate tints are a mixture of the two. The daguerreotype as at present produced shows only the effect of lights and shade. It has not yet satisfactorily produced color. Occasionally indeed, in the hands of an artist, a single color is produced, and Becquerel, by the aid of a galvanic current traversing the plate while in the camera, has produced an occasional color (not the natural one). Mr. Hill, of Greene Co. N. Y., has been asserted to have produced the colors of nature, and plates so colored have been seen by a few; but whether from uncertainty in the use of the materials, or want of artistic finish in the plates so produced, the publication has not yet appeared. It may not be amiss to point out the road to success—it lies in the taking images more rapidly; more sensitive plates, and more powerful accelerators must be used. It is very probable that a *polished* surface is not that which is capable of receiving the colors; a surface chemically pure, yet not capable of reflection, will be likely to answer better; hence the newly electrotyped surface should be most effective, and when this is excited by more sensitive coatings than the present, it is likely that the colors of nature will be reflected as they impinge. There is no doubt that the coating with mercury covers these up, hence this must ultimately be dispensed with, as also the use of cloride of gold. Chloro-cromic acid is a powerful accelerator, and may be useful in the first stages; but the whole difficulty has not as yet been solved.

Daguerreotype plates may be etched and thus the art usefully applied to objects of natural history. To do this it is necessary to etch away the dark parts and leave the white untouched. The plate is immersed in a fluid consisting of dilute nitric acid, nitrous acid, chloride of sodium, and nitrate of potass. These two salts are decomposed when the fluid is heated and chlorine and nitrous acids are evolved, these attack and remove the silver or dark parts, but have no effect on the mercury, so that the lights of the picture form the etching ground, and protect these portions of the plate. Ammonia is used to wash the plate and remove the cloride of silver formed, and allow the etching being carried on further. The plate is now inked and allowed to dry, the surface is then polished, and gilded by the electrotype, those parts only taking the gold which had been polished previously. The plate may now be still further etched with nitric acid; the ink having been washed out by potash and the etching carried on until it has gone sufficiently deep. M. Claudet has obtained some beautiful engravings of the lower animals by this process.

Daguerreotye images and photographic impressions may be reproduced in the following manner:

The image is received in the camera obscura on a plate of silver, strongly iodized; the plate is then exposed to the vapour of mercury, but not to the action of hyposulphite of soda. It is then plunged into a solution of sulphate of copper, placing it for a few instants in communication with the negative pole of a battery and closing the circuit with a platina wire. The copper deposits itself only on the parts covered by the mercury, the iodide of silver not being a conductor of electricity. The plate is then washed with distilled water, then with the hyposulphite of soda to remove the iodide, and quickly dried over a spirit lamp. The image, in which the copper represents the light parts and the silver dark, is transferred, at least the copper, on very thin plates of gelatine. An inverted image is thus obtained, since the copper which is opaque, represents the light parts. The transfer is made by running on the plate a clear solution of gelatine, and allowing it to dry; after which the gelatinous foil on which the copper adheres, is attached. The negative proof obtained, the next part of the process is, to re-produce a positive image; for this purpose a sheet of photographic paper is taken, on which is carefully applied the proof in gelatine the face on which is the copper underneath. The whole is then exposed to diffused light during a quarter of an hour; the paper is then plunged into water in order to be washed, and then into a solution of hyposulphite of soda to remove the salt of silver; it is then washed in a large quantity of water and dried,, by this a perfect and positive reproduction of a daguerreotype image is obtained. If it be desired to obtain the reproduction of a drawing or an engraving, a negative proof is taken on a prepared iodized plate, in placing it over the design or engraving and exposing the whole to the light. It is then passed through the mercurial process and the series of operations above described.

The following improvement in the process of Daguerreotyping has just been discovered by Niepce, the first discoverer of the art. The engraving is to be submitted to vapor of iodine (at a temperature of 15 or 20 degrees) during about ten minutes; a longer time is necessary if the temperature be less elevated; ten grammes of iodine to be used per square of 4 inches. The paper intended to receive the impression is to be covered with a coat of paste, taking care previously to have it moistened with water containing one degree of pure sulphuric acid. The proofs, after being pressed with a linen cloth, present a design of admirable purity. These impressions, taken on paste will, however, in drying, become vaporous; but if taken on paper prepared with one or two layers of starch, the design will not only be clear, but will preserve much better. What is most extraordinary is, that many impressions may be taken from the same print without submitting it to a new preparation—the last proofs being always the clearest. Designs of various colors may thus be obtained according as the paste is more or less boiled, or according to the quantity of acid used. Proofs may also be taken on different metals by observing the following precaution. In submitting the engraving to the vapor of iodine, care should be taken to have it perfectly dry, in order that the white portions of it may become impregnated. In this case it should be exposed but a few minutes to the vapor. Let it be afterwards applied, without wetting it, to a plate of silver, and then placed under a press; at the end of five or six minutes there will be a most faithful reproduction of the original. By afterwards exposing the plate to the vapor of mercury, a proof similar to that of a daguerreotype is obtained.

It has been rumored, that at a meeting of the French Academy of Sciences, M. Niepce had declared his capability of taking the pictures in the natural colors; his process has not yet reached this country.

DAHLINE, the same as Inuline, the fecula obtained from elecampane, and analogous in many respect to starch. It is not employed in the arts.

DAIRY. An apartment in a house, or a separate building, for the purpose of holding milk and manufacturing it into butter, cheese, or other dairy produce. On a small scale, where butter only is made from milk, the dairy may be a room in the north side of the dwelling house; or it may form one of the offices connected with the kitchen court. The requisites for the room to contain the milk are—an equal temperature throughout the year, viz: between 48° and 55°; sufficient ventilation to carry off all bad smells and impurities in the air; and the exclusion of flies and other insects. An equable temperature is maintained by thick or by hollow walls, and by double windows. In winter the temperature is somewhat raised by the warm milk, and in summer it is cooled to the degree required by ventilation and the evaporation of water poured on the floor. The ventilation is effected by opening the glazed sashes of the windows, and supplying their places by wire shutters, and indeed one of the best modes of arranging the windows of a dairy is to have wooden shutters outside for closing in the most severe weather in winter; next, a fixed frame of wire-work to exclude the flies; and within this, at three or four inches distance, the glazed sash, which should be made to open. A dairy on a large scale is most conveniently arranged as a detached building; in which case, it contains a milk-room, a churning-room, and a dairy scullery, or place for scalding the utensils. If cheese is to be made, a room will be required for a cheese press and another for drying the cheeses.

DAMASCUS BLADES, are swords or cimeters, presenting upon the surface a variegated appearance of *watering*, as white, silvery, or black veins, in fine lines, or fillets; fibrous, crossed, interlaced, or parallel, &c. They are brought from the East, being fabricated chiefly at Damascus, whence their name. Their excellent quality has become proverbial; for which reason these blades are much sought after by military men, and are high priced. The oriental processes have never been satisfactorily described; but of late years methods have been devised in Europe to imitate the fabric very well.

Clouet and Hachette pointed out the three following processes for producing Damascus blades: 1, that of *parallel fillets*; 2, that by *torsion*; 3, the *mosaic*. The first, which is still pursued by some French cutlers, consists in scooping out with a graving tool the faces of a piece of stuff composed of thin plates of different kinds of steel. These hollows are by a subsequent operation filled up, and brought to a level with the external faces, upon which they subsequently form tress-like figures. 2. The method of torsion which is more generally employed at present, consists of forming a bundle of rods or slips of steel, which are welded together into a well-wrought bar, twisted several times round its axis. It is repeatedly forged, and twisted alternately; after which it is slit in the line of its axis, and the two halves are welded with their outsides in contact; by which means their faces will exhibit very various configurations. 8. The mosaic method consists in preparing a bar, as by the torsion plan, and cutting this bar into short pieces of nearly equal length, with which a fagot is formed and welded together; taking care to preserve the sections of each piece at the surface of the blade. In this way, all the variety of the design is displayed, corresponding to each fragment of the cut bar.

The blades of Clouet, independently of their excellent quality, their flexibility, and extreme elasticity, have this advantage over the oriental blades, that they exhibit in the very substance of the metal, designs, letters, inscriptions, and, generally speaking, all kinds of figures which had been delineated beforehand.

Notwithstanding these successful results of Clouet, it was pretty clear that the watered designs of the true Damascus cimeter were essentially different. M. Bréant has at last completely solved this problem. He has demonstrated that the substance of the oriental blades is a cast-steel more highly charged with carbon than our European steels, and in which by means of a cooling suitably conducted, a crystallization takes place of two distinct combinations of carbon and iron. This separation is the essential condition; for if the melted steel be suddenly cooled in a small crucible or ingot, there is no damascene appearance.

DAMASKEENING. The art of inlaying iron and steel with gold and silver, originally practised at Damascus in Syria.

DAMASSIN. A species of woven damask with gold and silver flowers.

DAMPER. An iron plate sliding backwards and fowards in a groove, and so arranged as to enlarge or contract and occasionally close the chimneys of furnaces, steam boilers, &c., so as to increase or diminish the draught of air through the fire, and consequently regulate the intensity of the combustion.

DAMPS. The noxious exhalations of mines and excavations. The carburetted hydrogen of coal mines is called *Fire Damp*; carbonic acid is termed *Choke Damp*.

DATHOLITE or DATOLITE. A mineral compound of lime, silica, and boracic acid, a boro silicate of lime. It becomes opaque when heated.

DAVIT. A piece of timber used in managing the anchor.

DAVITE. Fibrous sulphate of alumina, found near Bogota in Columbia.

DEAD BEAT. In clock-work (called also *dead scapement*, or *scapement of repose*), a peculiar kind of scapement invented by Mr. George Graham about the year 1700, with a view to lessen the effect of the wheel-work on the motion of the pendulum; and acquired its name from the circumstance that the seconds' index stands still after each drop, whereas the index of a clock with a *recoiling* scapement is always in motion, hobbling backward and forward.

DEAD LIGHTS. Strong wooden posts or shutters, put over the glass-windows of the cabin in bad weather, as a defence against the sea.

DEAD RECKONING. A term used in navigation to express the estimation that is made of a ship's place without having recourse to observation of the celestial bodies. It is made by observing the way she makes by the log, and the course on which she has been steered, making allowance for drift, leeway, &c.

DECANTATION. The pouring off a clear liquid from its subsidence or residue; it is often resorted to in the chemical laboratory instead of filtration, the clear supernatant liquor being poured or syphoned off from precipitates, which may thus be repeatedly washed or edulcorated, so as to free them from all soluble matters.

DECARBONIZATION OF CAST IRON. This process is resorted to in order to convert cast iron into steel, or by a further decarbonization to reduce it to the state of malleable iron; hence, many articles which were formerly exclusively manufactured of wrought iron are now cast, and afterwards decarbonized—such as horseshoes, &c.; and in other cases various cutting instruments are cast, and afterwards brought to a proper hardness by a similar process. The articles to be decarbonized are packed in finely powdered hæmatite, or native oxide of iron, and exposed for a sufficient time to a high red heat. It is often necessary to mix iron filings or turnings with hæmatite; these substances, thus applied, gradually abstract the excess of carbon in cast iron, and reduce it to a state analagous to that of steel; or, by a longer continuance of heat, to that of soft iron. In some cases, however, the process seems rather to affect the texture and mechanical properties than the composition of the iron, and is therefore more analogous to annealing.

DECOMPOSITION, is the separation of the constituent principles of any compound body. The following table, the result of important researches recently made by M. Persoz, professor of chemistry at Strasburgh, shows the order in which decompositions take place among the successive substances, diminishing in power from above downwards.

Nitric Acid.	Muriatic Acid.
Oxide of Magnesium	Oxide of Magnesium
— Silver	— Cobalt
— Cobalt	— Nickel
— Nickel	Protox. of Mercury
Protox. of Cerium	— Cerium
Oxide of Zinc	Oxide of Zinc
Protox. of Manganese	Protox. of Manganese
Oxide of Lead	— Iron
— Cadmium	— Uranium
— Copper	— Copper
— Glucinum	— Tin
— Alumium	Oxide of Glucium
— Uranium	— Aluminum
— Chromium	— Uranium
Protox. of Mercury	— Chromium
Oxide of Mercury	— Iron
— Iron	— Tin
— Bismuth	— Bismuth
—	— Antimony

The study of the tables of decomposition are of the utmost importance to the practical and manufacturing chemist, as they are the means of protecting him from much waste and loss.

DECREPITATION, is the crackling noise, attended with the flying asunder of their parts, made by several salts and minerals, when heated. It is caused by the unequal sudden expansion of their substance by the heat. Sulphate of baryta, chloride of sodium, calcareous spar, nitrate of baryta, and many more bodies which contain no water, decrepitate most violently, separating at the natural joints of their crystalline structure.

DEFECATION. The freeing from dregs or impurities.

DEFLAGRATION. The sudden blazing up of a combustible; as of charcoal or sulphur when thrown into melted nitre.

DELPHINIA. The vegeto alkaline principle of the *Delphinium staphysagria*, or stavesacre. It is poisonous.

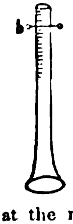
DELIQUESCENT, is said of a solid which attracts so much moisture from the air as to become spontaneously soft or liquid; such as potash and muriate of lime.

DEPILATORY, is the name of any substance capable of removing hairs from the human skin without injuring its texture. They act either mechanically or chemically. The first are commonly glutinous plasters formed of pitch and resin, which stick so closely to the part of the skin where they are applied, that when removed, they tear away the hairs with them. This method is more painful, but less dangerous than the other, which consists in the solvent action of a menstruum, so energetic as to penetrate the pores of the skin, and destroy the bulbous roots of the hairs. This is composed either of caustic alkalies, sulphuret of baryta, or arsenical preparations. Certain vegetable juices have also been recommended for the same purpose; as spurge and acacia. The bruised eggs of ants have likewise been prescribed. But the *oriental rusma* yields to nothing in depilatory power. Gadet de Gassincourt has published in the *Dictionnaire des Sciences Medicales*, the following recipe for preparing it.

Mix two ounces of quicklime with half an ounce of orpiment or realgar, (sulphuret of arsenic;) boil that mixture in one pound of strong alkaline ley, then try its strength by dipping a feather into it, and when the flue falls off, the *rusma* is quite strong enough. It is applied to the human skin by a momentary friction, followed by washing with warm water. Such a caustic liquid should be used with the greatest circumspection, beginning with it somewhat diluted. A soap is sometimes made with lard and the above ingredients; or soft soap is combined with them; in either case to form a depilatory pommade. Occasionally one ounce of orpiment is taken to eight ounces of quicklime, or two to twelve, or three to fifteen; the last mixture being of course the most active. Its causticity may be tempered by the addition of one-eighth of starch or rye flour, so as to form a soft paste, which being laid upon the hairy spot for a few minutes, usually carries away the hairs with it.

DESTRUCTIVE DISTILLATION. A term applied to the distillation of organic products at high temperatures, by which the ultimate elements are separated or evolved in new combinations. The destructive distillation of coal is resorted to for the production of gas, and that of bone for the production of ammonia, and of wood for the formation of vinegar.

DETONATING TUBE. A stout glass tube, used in the chemical laboratory for the detonation of gaseous bodies. It is generally, as represented in the annexed cut, graduated into centesimal parts, and perforated by two opposed wires, for the purpose of passing an electric spark through the gases which are introduced into it, and which are confined within it over water or mercury. When a detonating tube is used over either of these fluids, the smallest possible quantity of explosive gas should be introduced into it, as in consequence of the expansion which ensues, a portion is apt to be forced out at the moment of the explosion. The tube, when used, should be firmly held: a spring is sometimes substituted for the grasp of the hand, but it is inconvenient.



DETONATING POWDER. A term applied in chemistry to fulminating mercury and silver, and to other compounds which suddenly explode when struck or heated. Some of these compounds have lately been much used for the ignition of gunpowder in percussion locks.

DETONATION. When chemical combination or decomposition is sudden and attended by flame and explosion, it is often said to be effected by *detonation*. If a mixture of hydrogen gas and oxygen be inflamed by the electric spark or by a taper, it burns rapidly and with explosion, and is said to *detonate*. When a grain or two of phosphorus is mixed with chlorate of potassa and struck with a hammer, the mixture detonates.

DETRITUS. A geological term applied to deposits composed of various substances which have been comminuted by attrition. The larger fragments are usually termed *debris*; those which are pulverized, as it were, constitute *detritus*. Sand is the detritus of siliceous rocks.

DEUTOXIDE, literally means the second oxide; but is usually employed to denote a compound containing two atoms or two prime equivalents of oxygen to one or more of a metal. Thus we say deutoxide of copper, and deutoxide of mercury. Berzelius has abbreviated this expression by adopting the principles of the French nomenclature of 1787; according to which the higher stage of oxydizement is characterized by the termination *ic*, and the lower by *ous*, and he writes accordingly cupric and mercuric, to designate the deutoxides of these two metals; cuprous and mercurous, to designate their protoxides.

DEXTRINE. This substance has exactly the same chemical composition as starch, consisting of 24 atoms of carbon, 20 of hydrogen, and 10 of oxygen (Dumas); but it is distinguished from starch by its solubility in cold water, like gum, and not being affected by iodine. British gum, as it is called, or roasted starch, is merely dextrine somewhat discolored; a substance apparently used for the paste on the queen's head British letter-stamps. A process discovered by M. Payen, and patented in France by M. Henzé, for making dextrine, consists in moistening one ton of dry starch with water containing 4½ lbs. of strong nitric acid. The starch thus uniformly wetted, is made up into small bricks or loaves, and dried in a stove. It is then rubbed down into a coarse powder, and exposed in a stove-room to a stream of air heated to about 160° F. Being now triturated, sifted, and heated in a stove to about 228° F., it forms a perfect dextrine of a fair color; because the acid acts as a substitute for the higher heat, used in making the British gum. Such an article makes a fine dressing for muslin and silk goods, and is much employed in French surgery, for making a stiff paste-support to the bandages of fractured limbs.

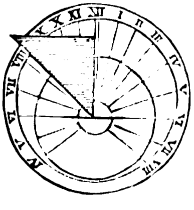
DIALS are instruments known to and constructed by the ancients, for the measurement of time.

In constructing a sun-dial, the object is to find, by means of his shadow, the sun's distance at any time from the meridian. When this distance is known, the hour is also known, provided we suppose the sun's apparent motion to be uniform, and that during the whole course of a day he moves in a circle parallel to the equator. Neither of these conditions is, in fact, accurately fulfilled, but the error which this gives rise to is of small amount; and it is, moreover, sufficiently obvious that the use of a dial is not to indicate the hour with astronomical precision, but merely to give such an approximation as is necessary for the purposes of civil life.

Dials are usually constructed on an immovable surface, and admit of an infinite number of different constructions, all depending on the nature of the surface and its position with regard to the equator of the earth. The general principles, however, are the same in all, and depend on the simplest elements of geometry and astronomy. The first part that claims attention is the *style* or *gnomon*, or axis of the dial, which is usually a cylindrical rod, or the edge of a thin plate of metal. The style must be directed perpendicularly to the terrestrial equator; in which direction it may be considered, on account of the smallness of the earth's diameter in comparison of the distance of the sun, as coinciding with the axis of the diurnal rotation; consequently the plane which passes through the style and its shadow on the surrounding surfaces, and which always passes through the centre of the sun, will be an hour plane, and turn with the sun as the sun turns round the style by the effect of the diurnal motion. All that remains to be done, in addition, is to discover, and describe, for the different hours of the day, the intersections of this variable hour plane with the surface on which the dial is to be constructed. On these intersections the shadow of the style will be projected every day at the same hour; because at the same hour the sun must have returned to the same hour plane, although his distance from the equator may be different.

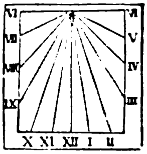
From these considerations it is manifest that the whole theory of dialling is comprehended in the solution of this general problem:—"Twelve planes all intersecting each other in the same straight line, and making with each other equal angles of 15°, being given in position; to find the intersections of those planes with any surface whatever, also given in form and position." The surface which intersects the hour planes may be of any kind whatever, but for obvious reasons it is generally a plane; and when its position with respect to the common intersection of the hour planes (which is the style of the dial) and to any one of those planes is given, the *traces* or intersections, which are in this case all straight lines, are the hour lines on the dial, and easily calculated by the ordinary rules of trigonometry or geometry.

According to the position of the dial with respect to the horizon of the place, the dial is *horizontal*, *vertical*, or *inclined*.



The most common construction is the *Horizontal Dial*, or that in which the plane of the dial is parallel to the horizon, and consequently makes with the style an angle equal to the latitude of the place. At the equator, this is the same as the polar dial; but at all other places, the hour lines intersect each other in the point in which the style intersects the plane of the dial, which point is called the centre, and the angles they make with one another, or with the XII hour line, depend on the latitude.

After the horizontal dials, the construction most frequently employed is that in which the plane of the dial is vertical; for example, when fixed on the wall of a house. In this case, the positions of the different hour lines depend on the latitude of the place and on the aspect of the dial; that is to say, its position with respect to the meridian. If the dial is perpendicular to the meridian, it is a *south dial*, or *north dial*, according as it faces the south or north. (The vertical south dial is represented in the annexed figure.) When not perpendicular to the meridian, the vertical dial is said to be *declined*. The formula for the hour lines of a south vertical dial differs from that for a horizontal dial in no respect excepting that the sine of the latitude is changed into the cosine, the cause of which will be obvious when it is considered that the plane of the dial in passing from the horizontal to the south vertical direction preserves its inclination to the different hour planes unaltered; while the angle which it makes with the style, or the axis of the earth, is the complement of the angle it made with the same line in its former position. Let y, therefore, be the hour angle at the centre of the dial; and putting, as before, $h =$ the hour from noon, and $l =$ the latitude, the formula for the south vertical dial is $\tan. y = \tan. h \cos. l$: whence it follows that a horizontal dial constructed for any given latitude will be a south vertical dial for any place of which the latitude is the complement of the latitude of the former place,—a property which was discovered by the Arabians. The hour lines of the vertical north dial are found exactly in the same way as those of the south dial.



DIAMOND. (A corruption of *adamant*). The most valuable of the precious stones. Diamonds were originally discovered in Bengal, and in the Island of Borneo. About the year 1720 they were found in Brazil. One lately found at Bahia was worth $225,000, though sold by the negro finder for $175. They always occur in a detached state in alluvial soil. The primitive crystalline form of the diamond is a regular octahedron, of which there are numerous modifications. Diamonds are found of all colors: those which are colorless, or which have some very decided tint, are most esteemed; the latter, however, are rare. Those which are slightly discolored are the least valuable. The diamond is the hardest known substance, and can only be polished by its own dust or powder. The art of splitting or cutting and polishing this gem, though probably of remote antiquity in Asia, was first introduced into Europe, in 1486, by Louis Berghem, of Bruges, who accidentally discovered that by rubbing two diamonds together their surfaces might be abraded. They are cut chiefly into two forms, *rose* and *brilliant:* the latter have the finest effect, but require a sacrifice of a larger portion of the gem; so that the weight of an ordinary polished diamond often does not exceed half that of the rough gem. The largest known diamond is probably that mentioned by Tavernier, in possession of the great mogul; it was found in Golconda in 1550; is of the size of half a hen's egg, and said to weigh 900 carats.

The next most valuable diamond in the world has lately come into the possession of Queen Victoria, and was exhibited in the World's Fair. It was brought from the East Indies, and presented to the queen by the East India Company; it is called the "Koh-i-Noor" (Mountain of Light). All the natives of Hindostan have heard of it, and it has had a mythological fame for a number of centuries. Its possession by any prince was superstitiously held to be the type of dominion. It was discovered in the famous diamond mines of Golconda, but when is unknown. It was a state jewel of the Delhi Emperors until 1739. In that year the Persian warrior, Nadir Shah, conquered the Delhi monarch, and carried away as his most precious trophy, the "Koh-i-Noor." It afterwards came into the possession of the Meers of Affghan, and was an heir loom in the family of Ahmed Khan Abdali, and was carried to Lahore by the fugitive prince Shah Shooja, from whom it was extorted by the basest of means—starvation. This was the hospitality of the Sikhs. By the conquest of the Sikh territory, in 1848, this diamond came into the possession of Lord Dalhousie, according to stipulation, to be presented to the queen. Its value is about eight millions of dollars; it weighs 280 carats, and is of the finest water. It never has been in a dealer's hands, but has descended, either by fraud or force, from one prince to another. Its shape is like the pointed half of a hen's egg.

Among the crown jewels of Russia is a magnificent diamond, weighing 195 carats: it is of the size of a pigeon's egg, and was purloined from a brahminical idol by a French soldier; it passed through several hands, and was ultimately purchased by the Empress Catharine for the sum of 90,000*l.* and an annuity of 4,000*l.* Perhaps the most perfect and beautiful diamond hitherto found is a brilliant brought from India by a gentleman of the name of Pitt, who sold it to the recent Duke of Orleans for the sum of 100,000*l.* It weighs about 136 carats, or 544 grains.

That the diamond is combustible was first proved by the Florentine academicians in 1694, who found that when exposed to the heat of the sun concentrated in the focus of a large lens, it burned away with a blue lambent flame. The *products* of its combustion were first examined by Lavoisier, in 1772, who showed that when it was burned in air or oxygen it produced carbonic acid; subsequent experiments have shown that nothing but carbonic acid is thus formed; and hence it is proved that the diamond is charcoal or carbon in a pure and crystalline form.

On the banks of the river Nikolaiefska, Tobolsk, in Siberia, in the midst of the auriferous sand washings, has been discovered a mine of stones resembling diamonds; they are a little less heavy and hard, but are harder than granite. It is proposed to call them Diamantoid. Diamond dust is used for working cameos, polishing brilliants, and sharpening cutlery.

Diamonds are valued by multiplying the square of their weight by the value of each carat. Allowing a rough diamond to weigh 4 carats, and the value of each carat is $8, then 4×4=16×8=$128, the value of a rough diamond. Manufactured or cut diamonds, have their values found by doubling the weight—for example, a cut diamond of two carats, double the 2, thus 4×4=16; multiply as before 16×8=128, the value of a cut diamond 2 carats fine. Diamonds are weighed by the carat of 3¼ grains Troy weight.

Diamonds, *cutting of.* Although the diamond is the hardest of all known substances, yet it may be split by a steel tool, provided a blow be applied; but this requires a perfect knowledge of the structure, because it will only yield to such means in certain directions. This circumstance prevents the workman from forming facettes or planes generally, by the process of splitting; he is therefore obliged to resort to the process of abrasion, which is technically called cutting. The process of cutting is effected by fixing the diamond to be cut on the end of a stick or handle, in a small ball of cement, that part which is to be reduced being left to project. Another diamond is also fixed in a similar manner; and the two stones being rubbed against each other with considerable force, they are mutually abraded, flat surfaces, or facettes, being thereby produced. Other facettes are formed by shifting the diamonds into fresh positions in the cement, and when a sufficient number are produced, they are fit for polishing. The stones, when cut, are fixed for this purpose, by imbedding them in soft solder, contained in a small copper cup, the part or facette, to be polished, being left to protrude.

DIAMOND MICROSCOPES were first suggested by Dr. Goring, and have been well executed by Mr. Pritchard. Previous to grinding a diamond into a spherical figure, it should be ground flat and parallel upon both sides, that by looking through it, as opticians try flint glass, we may see whether it has a double or triple refractive power, as many have, which would render it useless as a lens. Among the fourteen different crystalline forms of the diamond, probably the octahedron and the cube are the only ones that will give single vision. It will, in many cases, be advisable to grind diamond lenses plano-convex, both because this figure gives a low spherical aberration, and because it saves the trouble of grinding one side of the gem. A concave tool of cast iron, paved with diamond-powder, hammered into it by a hardened steel punch, was employed by Mr. Pritchard. This ingenious artist succeeded in completing a double convex of equal radii, of about one-twenty-fifth of an inch focus, bearing an aperture of one-thirtieth of an inch with distinctness upon opaque objects, and its entire diameter upon transparent ones. This lens gives vision with a trifling chromatic aberration; in other respects, like Dr. Goring's Amician Reflector, but without its darkness; its light is said to be superior to that of any compound microscope whatever, acting with the same power and the same angle of aperture. The advantage of seeing an object without *aberration* by the interposition of only a single magnifier, instead of looking at a picture of it with an eye-glass, is evident. We thus have a simple direct view, whereby we shall see more accurately and minutely the real texture of objects.

DIAPER. A woven linen ornamented with patterns, and used for towels and table-linen; it sometimes resembles an inferior kind of damask. It is said to have been originally manufactured at Ypres in Flanders: whence the term d'Ypres, corrupted into diaper.

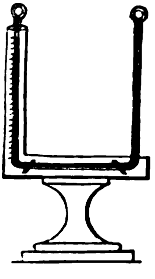
DIAPHANOUS. A term applied to bodies which permit the light to pass through their substances. It is the synonyme of translucent. A body which allows the forms of objects to be seen through it is transparent.

DIASPORE. A laminated mineral, composed of 80 alumina, 18 water, 3 oxide of iron. A small fragment decrepitates when heated, and is dispersed in numerous fragments: hence its name.

DIASTASE. A peculiar substance generated during the germination of barley, wheat, &c., which tends to accelerate the formation of sugar during the fermentation of worts. It is precipitated from infusions of bruised malt by alcohol. It is the principle which, by its reaction on starch, tends to develop sugar in the processes of germination and malting.

DIE, in coinage, is the instrument by which the impressions are given upon the various denominations of coin. The following is an outline of the *die manufacture:* The engraver selects a forged plug of the best cast steel of proper dimensions for his intended work, and having carefully annealed it, and turned its surfaces smooth in the lathe, proceeds to engrave upon it the intended device for the coin. When this is perfect, the letters are put in, and the circularity and size duly adjusted; it is then hardened, and is termed a *matrix*. Another plug of soft steel is now selected, and the matrix being carefully adjusted upon it, they are placed under a very powerful fly-press, and two or three blows so directed as to commence an impression of the matrix upon the plug; this is then annealed, and the operation repeated till the plug receives a perfect impression of the work upon the matrix. This impression is of course in *relief*, the original work upon the matrix being indented, and produces what is termed the *punch*. This being duly shaped in the lathe, is hardened, and is employed in the production of impressions in soft steel or *dies*, which, being properly turned and hardened, are exact *fac-similes* of the original matrix, and are used in the process of *coinage*. When a pair of dies are made of good steel duly hardened and tempered, and are carefully used, they will sometimes yield from two to three hundred thousand impressions before they become so far worn or injured as to require to be removed from the coining presses.

DIFFERENTIAL THERMOMETER. An ingenious instrument of great use in experimental philosophy, for measuring very small differences of temperature; invented and re-applied by Sir John Leslie, though the idea of an instrument of the same kind seems to have long before been suggested by Sturmius. The differential thermometer is described by Leslie, in his *Experimental Inquiry into the Nature and Propagation of Heat*, nearly as follows: Two glass tubes of unequal lengths, each terminating in a hollow ball, and having their bores somewhat widened at the other ends, a small portion of sulphuric acid tinged with carmine being introduced into the ball of the longer tube, are joined together by the flame of a blowpipe, and afterwards bent into nearly the shape of the letter U; the one flexure being made just below the joining, where the small cavity facilitates the adjustment of the instrument, which, by a little dexterity, is performed by forcing with the heat of the hand a few minute globules of air from the one ball into the other. The balls are blown as equal as the eye can judge, and from four-tenths to seven-tenths of an inch in diameter. To one of the legs of the thermometer a scale is attached; and the liquid in the tube is so disposed that it stands in the graduated leg opposite the zero of the scale, when both balls are exposed to the same temperature. From this construction of the instrument, it is easy to see that it is affected by the difference only of heat in the two balls. As long as both balls are of the same temperature, whatever this may be, the air contained in the one will have the same elasticity as that contained in the other; and consequently the intercluded colored liquid, being thus pressed equally in opposite directions, remains stationary. But if, for instance, the ball which holds a portion of the liquor be warmer than the other, the superior elasticity of the confined air will drive it forwards, and make it rise in the opposite branch above the zero, to an elevation proportional to the excess of elasticity or of heat. Sulphuric acid is chosen as the liquor best adapted to the purpose; because it is not vaporizable, and consequently does not by its vapor affect the pressure of the air above it. The carmine is used to render it more easily visible.



DIGESTER is the name of a strong kettle or pot of small dimensions, made very strong, and mounted with a safety valve in its top. Papin, the contriver of this apparatus, used it for subjecting bones, cartilages, &c., to the solvent action of high-pressure steam, or highly heated water, whereby he proposed to facilitate their digestion in the stomach. This contrivance is the origin of the French cookery pans, called *autoclaves*, because the lid is self-keyed, or becomes steam-tight by turning it round under clamps or ears at the sides, having been previously ground with emery to fit the edge of the pot exactly. In some autoclaves the lid is merely laid on with a fillet of linen as a lute, and then secured in its place by means of a screw bearing down upon its centre from an arched bar above. The safety valve is loaded either by a weight placed vertically upon it, or by a lever of the second kind pressing near its fulcrum, and acted upon by a weight which may be made to bear upon any point of its graduated arm.

Chevreul has made a useful application of the digester to vegetable analysis. His instrument consists of a strong copper cylinder, into which enters a tight cylinder of silver, having its edge turned over at right angles to the axis of the cylinder, so as to form the rim of the digester. A segment of a copper sphere, also lined with silver, stops the aperture of the silver cylinder, being applied closely to its rim. It has a conical valve pressed with a spiral spring, of any desired force, estimated by a steelyard. This spring is inclosed within a brass box perforated with four holes; which may be screwed into a tapped orifice in the top of the digester.

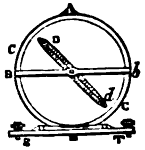
A tube screwed into another hole serves to conduct away the condensable vapors at pleasure into a Woulfe's apparatus.

DIMITY is a kind of cotton cloth originally imported from India, and now manufactured in great quantities in various parts of Britain, especially in Lancashire. Dr. Johnson calls it *dimmity*, and describes it as a kind of fustian. The distinction between fustian and dimity seems to be, that the former designates a common twilled cotton cloth of a stout fabric, which receives no ornament in the loom, but is most frequently dyed after being woven. Dimity is also a stout cotton cloth, but not usually of so thick a texture; and is ornamented in the loom, either with raised stripes or fancy figures; is seldom dyed, but usually worn white, as for bed and bed-room furniture. The striped dimities are the most common; they require less labor in weaving than the others; and the mounting of the loom being more simple, and consequently less expensive, they can be sold at much lower rates.

DIPPEL'S OIL. An empyreumatic oil, produced during the destructive distillation of bone.

DIPPER. A name commonly given to the water-ouzel and other species of the genus *Cinclus*.

DIPPING NEEDLE. An instrument for showing the direction of the magnetic force of the earth. It is a magnetic needle, furnished with an axis at right angles to its length, and passing as exactly as possible through its centre of gravity, about which it moves in a vertical plane. When a needle thus mounted is placed any where not on the magnetic equator, it *dips*, or points downwards: and if the vertical plane in which it moves coincides with the magnetic meridian (which is always known by means of a variation compass), the position which it assumes shows at once the direction of the magnetic force; and the intersection of two or more directions, found by making the experiment at different places, indicates the place of the magnetic pole. Though the principles on which the dipping needle acts are abundantly simple, its practical construction is found to be exceedingly difficult. It must be accurately balanced on its axis; the axis must be placed exactly horizontal; the friction must be diminished to the utmost extent possible: and the adjustments can only be made when the needle is perfectly free from magnetism, and also secured from the effects of the magnetic influence of the earth. It must be subsequently magnetized, and during this process much care is required to guard against derangement. The simple construction is represented in the annexed figure. The needle D *d* consists of a flat oblong piece of steel, tapering to a point at both ends, and having a slender cylindrical axis passed through its centre of gravity. The axis moves freely in circular holes made in the lateral horizontal bars H *h*, which support a vertical circular C C, graduated for the purpose of showing the inclination of the needle to the horizon.



The stand S. T, to which the circle is fixed, is provided with levels, and adjusted to horizontality by means of screws. But in the most improved form of construction of the dipping needle, the axis, instead of being a cylinder, is a knife edge, resting perpendicularly, like the supports of a pendulum, on two agate planes. A needle thus supported, however, must necessarily make small oscillations; consequently it must be so adjusted that when it points in the direction of the magnetic force, the knife edges may be perpendicular to the agate planes. The mean value of the angle of the dip must therefore be known previously to its construction; but it is the best adapted, on account of its delicacy, for ascertaining the minute variations of the dip at the same place. The angle of the dip, like that of the variation, changes its value even at the same place, following of course the motion of the magnetic poles, which, from the observations made by Scoresby, Parry, Ross, and others, in high latitudes, appear to have a motion westward, the annual amount of which is about 11′ 4″. In the summer of 1831, Commander Ross, in an excursion from the vessel in which his party were so long detained in the polar seas, reached a spot on the continent of North America, which had been calculated to be the position of the magnetic pole. There he found the dip of the needle to be 89° 59′, within one minute of the vertical; and compass-needles suspended in the most delicate manner possible exhibit no polarity whatever. The latitude of this spot is 70° 5′ 17″ north, and its longitude 96° 46′ 45″ west.

DISTILLATION. The evaporation

and subsequent condensation of liquids by means of a *still* and *refrigeratory*, or of a *retort* and *receiver*.

The discovery of the art of distillation is generally ascribed to the alchemists; but it was doubtlessly known in more remote ages to the Arabians, and by them probably derived from nations further east.

The process of distillation, though in continual use in the chemical and pharmaceutical laboratory, is carried on upon the most extensive scale for the production of ardent spirits in the *distilleries*. Under the words ALCOHOL, BRANDY, FERMENTATION, WINE, &c., will be found some details bearing upon the nature, sources, and production of spirituous liquors.

There are two distinct operations in the production of ardent spirits; the one is the conversion of certain vegetable principles into alcohol; and the other, the separation of the alcohol from the other substances with which it is necessarily blended during its production.

All those species of corn which are employed in breweries answer for distilleries; as wheat, rye, barley, and oats; as well as buckwheat, and maize or Indian corn. The product of spirits which these different grains afford, depends upon the proportion of starch they contain, including the small quantity of uncrystallizable sugar present in them. Hermstaedt, who has made exact experiments upon the subject, reckons a quart, (Prussian or British) of spirits, containing 30 per cent. of the absolute alcohol of Richter, for two pounds of starch. Hence 100 pounds of starch should yield 85 pounds of alcohol; or 4·375 gallons imperial, equal to 7.8 gallons of spirits, excise proof.

100 pounds of the following grains afford in spirits of specific gravity 0.9427, containing 45 per cent. of absolute alcohol, (= 9-11 of British proof,) the following quantities:—

Wheat, 40 to 45 pounds of spirits; rye, 86 to 42; barley, 40; oats, 36; buckwheat, 40; maize, 40. The mean of the whole may be taken at forty pounds, equal to 4¼ gallons imperial, of 0·9427 specific gravity = 8·47 gallons, at excise proof. The chief difference in these several kinds of corn consists in their different bulks under the same weight; a matter of considerable importance; for since a bushel of oats weighs little more than the half of a bushel of wheat, the former becomes for some purposes less convenient in use than the latter, though it affords a good spirit.

Barley and rye are the species of grain most commonly employed in the European distilleries for making whiskey. On this continent corn and potatoes are the chief materials used for producing alcohol.

The vegetable principle which is essential to the formation of alcohol is *sugar;* and this is sometimes used *directly*, as where molasses and analogous saccharine products are subjected to immediate fermentation; or it is *indirectly* obtained by subjecting amylaceous grains to certain processes, by which the starch they contain is first converted into sugar, and then that sugar afterwards alcoholized.

In distilleries the latter alternative is adopted; and various kinds of grain, but chiefly barley, wheat, and rye, with more or less malt, are subjected to the operation of *mashing*. For this purpose the ground grain and the bruised malt are duly mixed, and infused under constant agitation in a proper quantity of hot water in the *mash-tub;* the wort is then run off, and fresh water added, till the soluble materials of the grain are extracted.

In this way the mixed worts or *wash* is obtained, which is afterwards to be subjected to fermentation; but in the distilleries of Great Britain the operator is not, as in the brewery, left to his own judgment or convenience, but enforced to conform to the excise laws, which are of a very peremptory and often of a very unscientific character. By these laws the distiller is restricted in the density of his worts to specific gravities between 1050 and 1090; and in Scotland between 1030 and 1075. It is presumed that as those specific gravities, which are called 50 and 90, and 30 and 75, the actual quantity of saccharine or saccharifiable matter contained in each barrel (or 36 imperial gallons) amounts respectively to from 47½ lbs. to 85 lbs., and from 28 lbs. to 79 3-10 lbs. In this country the distiller is untrammelled.

When the wash above alluded to is adjusted as to density, it is run into the fermenting vats, where, mixed with a small quantity of yeast, it is subjected to the process of fermentation, which continues from six to ten or twelve days, the time required for its completion varying with the mass of liquid and with the temperature of the atmosphere.

During mashing, as well as during fermentation, the starch passes into sugar, and the sugar into alcohol; the consequence of which is that the wash gradually decreases in density or *attenuates;* and as soon as this attenuation has reached its maximum, which may be determined by the hydrometer, it should be distilled, in order to prevent the access of acetous fermentation.

In all large distilleries there are two sets of stills: one for the purpose of distilling from the wash a weak spirit, technically called *low wines;* and the other for redistilling (or *rectifying*) the low wines. In these distillations there passes over along with the first and last portions of the spirits a peculiar volatile oil of a disagreeable flavor and odor, and rendering the weaker spirit milky. These portions are called *faints*, and are carefully turned into separate receivers as soon as the appearance of the runnings from the worm-end indicates their presence.

The quantity of alcohol which may be obtained from a given quantity of sugar will depend upon the skill and care with which mashing, fermentation, and distillation have been respectively conducted; theoretically, 100 pounds of sugar are convertible into about 51 of alcohol and 49 of carbonic acid. The quantity of alcohol to be procured from different kinds of grain will also depend upon the same causes, and upon the quantity of sugar, and of starch and gum convertible into sugar, which each may contain.

Sometimes malt only is used in the distillery, in which case the distiller calculates in obtaining two gallons of whiskey of proof strength from each bushel of malt. In some distilleries as much as 3000 gallons per day are produced, and the worm of the still is passed into the body of a second still, so that the heat arising from the condensation in the worm raises the temperature in the second still, and thus economises fuel.

There is a kind of ardent spirits manufactured in Holland, vulgarly called Dutch gin, Hollands, and sometimes *genera*, from *genievre*, the French for juniper, a plant with the essential oil of whose berries it is flavored. One cwt. of ground malt mixed with two cwts. of rye meal are mashed for two hours, with about 450 gallons of water at the temperature of 160° F. The mash drawn off is reduced with cold water till the liquid part has the density of 45 lbs. per barrel, = specific gravity 1·047; and is then put altogether into the fermenting back at the temperature of 80° F. One or two gallons of yeast are added. The fermentation soon becomes so vigorous as to raise the heat to 90° and upwards, but it is not pushed far, being generally over in two days, when the gravity of the wash still indicates 12 lbs. of saccharum per barrel. By this moderate attenuation, like that practised by the contraband distillers of the Highlands of Scotland, it is supposed that the fetid oil of the husks is not evolved, or at least in very small quantity. The grains are put into the alembic along with the liquid wash, and distilled into low wines, which are rectified twice over, some juniper berries and hops being added at the last distillation. But the junipers are some times bruised and put into the mash. The produce of worts so imperfectly fermented, is probably little more than one half of what the British distiller draws from the same quantity of grain. But the cheapness of labor and of grain, as well as the superior flavor of the Skiedam spirits, enables the Dutch distiller to carry on his business with a respectable profit. In opposition to the above facts, Dubrunfaut says that about one third more spirits are obtained in Holland from grain than in France, because a very calcareous spring water is employed in the mashing operation. Were this account well founded, all that the distillers of other countries would have to do would be merely to introduce a portion of chalk into their mash tubs, in order to be on a par with the Dutch. But the statement is altogether a mistake.

In the vine countries, the inferior wines, or those damaged by keeping, as also a fermented mash of the pressed grapes, mixed with water, are distilled to form the *eau de vie de Cognac* of the French, called Brandy in this country. It contains less essential oil, and that of a more agreeable flavor, than corn spirits.

Of making whiskey from potatoes.—This root, in certain localities where it abounds at a moderate price, is an excellent material for fermenting into alcohol. When sound, it possesses from 20 to 25 per cent. of solid substance, of which starch constitutes at least three-fourths: hence 100 pounds contain from 16 to 22 pounds of starch susceptible of being saccharified. In the expressed juice there is a small quantity of tartaric acid.

As potatoes readily pass into the acetous fermentation, the admixture of the malt, the mashing and the cooling should be rapidly performed, while the utmost cleanliness must be observed.

The fermentation is brisk, probably from the agency of the albumen, and furnishes a good head of barm, which answers well for the bakers; 100 pounds of potatoes yield from 18 to 20 pounds measure of spirits, nine-elevenths of our excise-proof; or about 16 pounds measure of proof=about 1⅝ gallons.

It has been observed that after the month of December potatoes begin to yield a smaller product of fermented spirits; and when they have once sprouted or germinated, they afford very little indeed. From the difficulty of keeping and transporting potatoes, distillation from them, can never become general till some plan be adopted for overcoming these disadvantages.

When acetic ether is added to well purified or clean spirits, such as the distillers call silent whiskey, it gives it somewhat of the flavor of brandy. For this purpose, also, the spirits are rectified from bruised prunes, or the lees of the cognac distilleries, whereby they acquire additional flavor. The astringent taste of old brandy is imitated by the introduction of a little catechu into the British spirits. Burned sugar is employed as a coloring in these imitations. Butyric ether gives a pine-apple flavor.

DIVING BELL. An apparatus by means of which persons are let down and enabled to remain under water, and execute various operations: such as levelling or clearing the bottoms of harbors, preparing a foundation for buildings, bringing up sunken materials, &c. The principle of the diving bell depends on the impenetrability of atmospheric air, and may be illustrated by a very familiar experiment. Bring the edge of an inverted tumbler, or any close vessel, to the surface of water, and, keeping the mouth horizontal, press it down in the water. It will be seen that, though some portion of water ascends into the tumbler, the greater part of the space remains empty, or only filled with air; and any object placed in this space, though surrounded on all sides with water, would remain perfectly dry. In fact, the quantity of air remains the same, but it is compressed into a smaller volume, in proportion to the depth to which it is made to descend. Now, if we conceive a vessel of wood or iron, sufficiently capacious to hold several men, to be suspended by a chain, and lowered by means of weights attached to it, to any moderate depth under water, it is evident that they may remain there for a considerable time, and perform any operation that could be executed on land in the same confined space. The machine, however, as thus described, is liable to two great defects, which must be obviated by other contrivances before any great advantage can be derived from it. In the first place, as the air by its compressibility allows the water to enter the lower part of the bell, the dry space is not only diminished, but the bottom on which the bell rests, and where the operations are to be carried on, is also covered with water to a proportional depth. In the second place, the air within the bell, by repeated respiration, soon becomes mephitic, and unfit to support life; so that it is necessary to elevate the apparatus after short intervals, to admit a fresh supply.

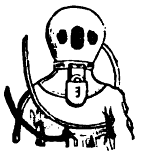
It is not known at what period the diving bell was invented. Beckmann, in his *History of Inventions*, mentions that at Toledo, in the sixteenth century, two Greeks, in the presence of the emperor Charles V. and several thousand spectators, let themselves down under water in a large inverted kettle with a burning light, and rose again without being wet. George Sinclair, the author of *Satan's Invisible World Displayed*, in his work entitled *Ars Nova et Magna Gravitatis et Levitatis*, mentions some attempts that were made about 1665 to raise, by means of a diving bell, the treasure from the ships of the Invincible Armada that went to the bottom near the Isle of Mull in the Hebrides, and describes the kind of bell that was employed. But, on account of the defects to which we have alluded, the diving bell continued to be of very little use till the time of Dr. Halley, who contrived a means of introducing fresh air into the bell while under water, and of allowing the mephitic or breathed air to escape. The bell he made use of he describes as having been of wood, containing about 60 cubic feet in its cavity, and of the form of a truncated cone, whose diameter at the top was three feet, and at the bottom five. This was coated with lead, so heavy that it could sink empty, and the weight so distributed about its bottom that it could only descend in a perpendicular direction. In the top a clear glass was fixed, to let in the light from above, and a cock to let out the air that had been breathed. To supply the air to the bell he caused a couple of barrels, of about 36 gallons each, to be cased with lead so as to sink empty, each of them having a bung-hole in its lowest part, to let in the water as the air in them condensed on their descent, and to let it out again when they were drawn up full from below. To a hole in the uppermost part of the barrels a trunk or hose was fixed, long enough to fall below the bung-hole, and kept down by a weight, so that no air could escape by the hose till its end was raised up. The barrels thus prepared were let down by the side of the bell. A man stationed on a stage suspended from the bell was ready to take up the hose; and, as soon as their ends were brought to the surface of the water in the barrels, all the air that was included in the upper parts of them was blown with great violence into the bell, while the water entered at the bung-holes below and filled the barrels. By means of this contrivance the air was not only kept fresh, but another great advantage was gained: namely, that by admitting a sufficient quantity of it the whole of the water was expelled from the inside of the bell, and the bottom of the sea laid dry.

By means of this contrivance for the admission of fresh air, it was now possible to remain for any length of time under water; but the use of the apparatus was still found to be attended with some inconveniences, and even considerable danger. The divers within the bell having no power over it, its rising or sinking depends entirely upon the people at the surface of the water; and as the bell, even when in the water, has a considerable weight, there is always a possibility of the chain by which it is raised breaking, which would inevitably be attended with the destruction of the divers. Another danger, still more to be apprehended, is, that if the mouth of the bell in its descent should come upon a sunken ship, or a rock projecting abruptly from the bottom, it might be overset before any signal could be given to those above. These defects were obviated by the very ingenious contrivances of Mr. Spalding of Edinburgh. In order to avoid the risk of being upset when the bell descends on a rocky or uneven bottom, he suspended a considerable weight, which is called a *balance weight*, below the bell, by a rope passing over a pulley fixed in the inside; and the other weights attached to the bell being so adjusted that they could not sink it without the balance weight, as soon as the latter rested on the ground the bell remained suspended in the water. In case of the mouth of the bell being caught by any obstacle, the balance weight is immediately lowered, till it rests on the bottom; and as the bell, when thus relieved, is buoyant, the divers, having disengaged it from the rock, have it in their power either to descend by pulling in the rope, or by allowing it to run to ascend to the surface. Another contrivance of Mr. Spalding deserves mention. He divided the bell into two compartments, the one above the other, and communicating by means of a stopcock. The divers are stationed in the lower one, and the weights are so adjusted that when the cavity above is empty the bell is buoyant; when it is filled with water, the bell sinks. Immediately above the partition are some slits in the sides of the bells; and at the top is an orifice, which can be opened or shut at pleasure. Suppose now, this orifice being open, the bell is required to be lowered; as it descends, the water enters at the slits, and the air escapes by the orifice. When the apparatus is entirely under water, and the cavity consequently completely filled, let the orifice be shut. The bell will now continue to descend; but if the stopcock communicating with the upper compartment be opened, the air will rush from the under to the upper, and displace a quantity of the water, and the apparatus will be lightened by the whole of the water so displaced. The divers have it thus in their power to regulate the descent or rise as they please. By admitting a certain quantity of air into the upper cavity, the descent of the bell is arrested; by admitting a greater quantity it becomes buoyant, and rises to the top. This method of constructing the diving bell has not, however, been adopted.

The greatest improvement on the diving bell, since that of Halley, was made by the celebrated Mr. Smeaton, and consists in forcing down a continued stream of air by means of an air-pump through a flexible tube; and this plan is now always adopted. In the year 1788, Smeaton constructed a diving bell to be used in the operations then contemplated at Ramsgate harbor on a new and improved plan. Instead of a bell-shaped vessel sunk by weights, his apparatus consisted of a square chest of cast iron, four and a half feet long, four and a half feet high, and three feet wide, affording sufficient room for two men under it. It was cast of such a thickness that its own weight was sufficient to sink it; and its thickness was greatest near the mouth or lower part, to prevent it from being easily overset. This construction of the diving bell gave the men within it no power of raising or sinking it; but as the apparatus was made to be used at a place where the nature of the bottom was known, this advantage was not considered of great consequence; and, in fact, it is found by experience that it is better to leave the bell to be entirely guided from above. On account of the facility with which water conveys sound, the strokes of a hammer on the inside of the bell can be heard at a great distance; and the sound coming through the water has a peculiar character, which cannot be mistaken. By previous arrangements any directions can be given in this manner. For instance, one blow may denote more air; two, stand fast; three, heave up; four, lower down, and so on. With these successive improvements, the diving bell is found to be a most important machine in all the great operations to be performed under water. It was used with great advantage by Mr. Rennie in the construction of the various harbors he projected; and it has recently been successfully employed in deepening the Clyde between Glasgow and Greenock, and improving the condition of the river.

DIVING. The art of descending in water. Independently of the valuable native productions which are found at the bottom of the sea, such as pearls, coral, sponges, &c., the treasure which is so frequently carried down in wrecked vessels makes it an object of importance to be able to descend to the bottom and remain there long enough to execute the operations necessary to recover it. But without the assistance of some mechanical apparatus, it is extremely little that even the most practised divers can perform. A minute and a half, or two minutes, is the longest time that a diver, in general, can remain under water. Besides, on account of the loss of weight in water, the power which a man can exert is extremely small, unless borne down by a load which would entirely prevent him from rising again to the top. For these reasons, numerous projects have been brought forward to assist the natural powers of the body, and render diving an art of more extensive utility. In all these projects, the principal object aimed at is to supply the diver with fresh air and light, and leave him the free use of his arms, and the power of walking within a moderate range at the bottom. Borelli contrived an apparatus which he called a diving bladder; the bladder being of brass or copper, about two feet in diameter, to contain the diver's head, and fastened to a goat-skin covering exactly fitted to the shape of the head. An apparatus of this kind was successfully used by Mr. Deane on the west coast of Scotland, at Spithead, and at Donaghadee, where he brought up an immense number of dollars and various other articles from a vessel which had been wrecked there more than thirty years before.

The principal part of Mr. Deane's apparatus consists of a helmet of thin sheet copper, which covers the head of the diver, large enough to admit of free motion, and furnished with three eye-holes, covered with glass protected by brass wires. The helmet comes pretty well down over the breast and back, and is fastened by rivets to a waterproof canvass jacket so tightly that no water can penetrate. A leather belt passes round the diver, to which are attached two weights, one before and the other behind, each about 40 lbs. The belt is supplied with a buckle in front, which, in case of any accident happening, can be instantly undone. The diver is supplied with fresh air by means of a flexible water-proof pipe, which enters the helmet, and communicates with an air-pump, wrought above in the barge from which he descends. This pipe passes under the left arm of the diver, and enters the back of the helmet, being so contrived that the fresh air is made to impinge on the glasses; which in a great measure prevents their being dimmed by the moisture of the breath. From the back part of the helmet there is also led an eduction pipe, to allow the escape of the breathed air. A single line passes under the right arm to communicate with attendants at the surface. The diver descends from the side of the vessel, either by means of a rope or wooden ladder, loaded at the lower end, the weight being kept at a little height above the ground. When the diver descends to the bottom, the weight is let down, and the rope allowed to become slack, to prevent the motion of the boat from obstructing him. His motion is rendered



steady by heavy weights attached to his feet: and he carries a line in his hand, that he may, when necessary, guide himself back to the rope. A waterproof dress covers his body entirely; and he is thus enabled to remain under water five or six hours at once, all the while perfectly dry.

DIVISIBILITY. The property which all bodies possess of being separable into parts. It was a question formerly much agitated among philosophers, whether matter is divisible *in infinitum;* or whether a certain term does not exist beyond which the particles are reduced to simple atoms incapable of further division. The question is incapable of direct solution, and fortunately is of no importance to science; but the extent to which the actual subdivision of bodies has been carried in many cases in the arts may well be considered as prodigious. "In the gilding of buttons, 5 grains of gold, which is applied as an amalgam with mercury, is allowed to each gross; so that the coating left must amount to the 110,000th part of an inch in thickness. If a piece of ivory, or white satin, be immersed in a nitro-muriate solution of gold, and then exposed to a current of hydrogen gas, it will become covered with a surface of gold hardly exceeding in thickness the ten-millionth part of an inch.

"The solution of certain saline bodies, and of other colored substances, exhibits a prodigious subdivision and dissemination of matter. A single grain of the sulphate of copper, or blue vitriol, will communicate a fine azure tint to five gallons of water. In this case the copper must be attenuated at least ten million times; yet each drop of the liquid may contain so many colored particles, distinguishable by our unassisted vision. Odors are capable of a still wider diffusion. A single grain of musk has been known to perfume a room for the space of twenty years. Animal matter likewise exhibits in many instances a wonderful subdivision. The milt of a codfish when it begins to putrefy has been computed to contain a billion of perfect insects, so that thousands of these living creatures could be lifted on the point of a needle. But the infusory animalcules display in their structure and functions the most transcendant attenuation of matter. The *Vibrio undula*, found in duck weed, is computed to be ten thousand million times smaller than a hemp seed. The *Vibrio lineola* occurs in vegetable infusions, every drop containing myriads of these oblong points. The *Monas gelatinosa*, discovered in ditch water, appears in the field of a microscope a mere atom endued with life, millions of them playing like sunbeams in a single drop of liquid."

DOCIMASTIC ART. The art of assaying minerals or ores, with a view of determining the quantity of metal which they contain.

DOCK. An artificial basin for the reception of ships. Docks are of two sorts, wet and dry: the former are used for the purpose of loading and unloading a ship's cargo out of the influence of the tide, and are constructed with gates, which when shut keep the ship constantly on float at low water; the latter are intended for the building, repairing, or examination of ships, which are admitted into them at flood tide, and are so called because they are either left *dry* by the ebbing of the sea, or rendered so by the use of great flood gates or of pumps. A *naval dock* is a place provided with all sorts of naval stores, timber, and all the requisite machinery for ship-building.

DRAGON'S BLOOD is a resinous substance, which comes to us sometimes in small balls of the size of a pigeon's-egg, sometimes in rods, like the finger, and sometimes in irregular cakes. Its color, in lump, is dark brown red; in powder, bright red; friable; of a shining fracture; sp. grav., 1·196. It contains a little benzoic acid, is insoluble in water, but dissolves readily in alcohol, ether, and oils. It is brought from the East Indies, Africa, South America, as the produce of several trees, the *Dracæna Draco*, the *Pterocarpus santalinus*, the *Pterocarpus Draco*, and the *Calamus Rotang.*

Dragon's blood is used chiefly for tingeing spirit and turpentine varnishes, for preparing gold lacker, for tooth tinctures and powders, for staining marble, &c. According to Herbenger, it consists of 9·07 parts of red resin, 2 of fat oil, 3 of benzoic acid, 1·6 of oxalate, and 3·7 of phosphate of lime.

DRAINING. The art of freeing the surface of the soil from superfluous water, considered with reference to cultivated vegetables, and the health of man and animals. Water may become superfluous by being collected in the natural hollows on the surface, and thus forming bogs; by being retained in the surface stratum, in consequence of a retentive subsoil; or by oozing through a moist subsoil to the surface stratum, in consequence of supplies from subterraneous sources. Water collected in bogs, or marshy places, remains there, because it has no natural outlet, neither by an opening or hollow along the natural surface, nor by the porosity of the subsoil, in consequence of which the water might sink into it and disappear. The obvious mode of draining in the first case is by a trench or drain, so deep as to draw the water from the lowest parts of the hollow, bog, or marsh. Where water is retained in the surface soil in consequence of a retentive subsoil, as in the case of clays and many loams, the most effective mode is to cut a number of small drains parallel to and at short distances from one another; and by the tops of these drains reaching within an inch or two of the bottom of the surface soil, which in cultivation is turned over by the plough, they absorb the superfluous water that passes through this soil and carry it off. Or, should the land be in pasture, the tops of the drain should be brought within an inch or two of the grassy surface, so as to intercept the water, both oozing laterally from the surface soil, and vertically from among the leaves of the grass. It may be observed also that pasture lands on this description of retentive soil may be more readily drained when laid into ridges, and an underground drain formed under each furrow or surface drain. This, however, is not essential; and though furrows or surface drains would be no deformity in field culture, yet in lawns and parks the appearance of furrows would destroy the continuity and evenness of surface, which in lawns is one chief source of beauty. To drain the surface soil, where it is supplied by water from the subsoil, requires some knowledge of the strata of which the subsoil is composed. In general the strata composing the subsoil lie over one another in a direction more or less approaching to horizontal; and when the natural inclination of the surface is every where parallel to this strata beneath, the water, if it oozes out of the subsoil at all, will generally do so equally throughout the subsoil; and in such cases numerous drains at no great distance are required to carry it off, precisely as in the case of draining soils with retentive subsoils. But when the line of surface does not correspond with the line of substrata, but intersects this line, then water will generally be found oozing out at the line of intersection, technically called the cropping out of the strata. The quantity of water which will issue from these sections or croppings out of broken strata will depend on a great variety of circumstances, into which it is unnecessary here to enter; because in all cases the mode of draining is the same, viz., that of forming a drain parallel to the line of fracture of the strata. This drain in some cases is not required to extend the whole length of the line of the fracture; because if the strata have a double inclination, so as it were to conduct the water to one angle or point, a drain at that angle or point will carry off the whole of the superfluous water contained in the strata. The subsoil in some cases is composed of strata in a nearly vertical position, and in others of strata alternately depressed and elevated, so that a section through them would form a serpentine line; and sometimes the subsoil is composed of strata the layers of which have been broken up and jumbled together. All these, and other cases, are to be drained in one or more of the above described modes; that is, accumulated water, whether in the soil or above it, is to be let off by cuts or drains made at the lowest points of accumulation; and surface soil saturated with water, whether from greater atmospherical supplies than can be carried off by evaporation or can sink into the subsoil, or whether it arise from sources in the subsoil, is to be carried off by numerous drains close to one another, and the tops of which are the cultivated soil, or the permanent clothing of grass or other herbage.

Draining is not required in this country as much as in England; yet in very many instances, as in heavy clay soils and on low swamp lands, it should be the first step in the cultivation of the land. When the soil is porous, light, and sandy, drains are not required; or if so, need only be placed far apart and at great depth (below 5 feet): on clay lands they require to be closer, and about the depth of 30 or 36 inches. Draining tools and tiles are now coming into much use; and when it is considered that it raises the produce of the land to one third more, few intelligent farmers who cultivate *well* will neglect it. Pipe drains are better for general use than arch drains with flat soles, as the water is delivered quicker in its channel, and the latter is kept clean, not choking up: the latter, however, hold better in clay soils.

The top of every drain should be sufficiently far below the surface that the plough in passing over will not touch it.

DRILL. In mechanics, a small instrument of steel for perforating metals or hard substances. Its action is produced by communicating to it a very rapid rotation by means of a *drill-bow*.

Drill. In Agr., a machine for sowing agricultural seeds in rows; sometimes worked by the hand alone, and sometimes by the addition of a horse.

DRILL HUSBANDRY. In Agr., the cultivation of arable land, by sowing the crops in rows; the advantage of which is, that it admits of destroying the weeds, and stirring the soil in the intervals between the lines of plants. As this mode of cultivation requires some implements and machines not in use in the commoner kinds of farming, and as it is besides better adapted for some soils than for others, it is not so generally used as the obvious advantages attending it would lead us to expect.

DROSOMETER. Any instrument for measuring the quantity of dew that collects on the surface of a body exposed to the open air during the night. The first instrument for this purpose was proposed by Weidler. It consisted of a bent balance which marked in grains the preponderance which a piece of glass of certain dimensions, laid horizontally in one of the scales, had acquired from the settling and adhesion of the globules of moisture. A simpler and more convenient drosometer would be formed on the principle of the rain gauge; and in order to facilitate the descent of the dew down the sides of the funnel into the tube, a coat of delicate salt of tartar may be spread over the shallow surface. Dr. Wells, in making his celebrated experiments on dew, exposed a small quantity of wool to the open sky, and the difference in its weight when laid down and taken up showed the quantity of moisture it had imbibed in the interval.

DRUGGET. A coarse and flimsy woollen texture, chiefly used for covering carpets. It was formerly extensively employed as an article of clothing by the poorer classes, more especially of females; but this and similar fabrics are now almost wholly superseded by cotton goods, which induce greater cleanliness, and are less liable to retain infectious and contagious poisons.

DRY DISTILLATION. This term is applied to the distillation of substances *per se*, or without the addition of water: thus if we put wood into a retort or other distillatory apparatus, and subject it to heat, it yields tar, vinegar, water, and various gaseous and other matters, which are called the products of its *dry* or destructive distillation.

DRYING OIL. This term is generally applied to linseed and other oils which have been heated with oxide of lead: they are the bases of many paints and varnishes.

DRY ROT. A disease which attacks wood, rendering it brittle, and destroying the cohesion of its parts, is known by this name. It occurs among the timbers of ships, where it sometimes commits the most serious damage, and in damp ill-ventilated houses. It is usually ascribed to the attacks of fungi, especially to such as *Polyporus destructor* and *Merulius lachrymans*, whose filamentous spawn or thallus appears upon the surface, overspreading it like a tough thick skin of white leather; and there is no doubt of its being often connected with appearance of such fungi. But dry rot is certainly, in some cases, to be identified with the presence of a fungi of a more simple kind than those just mentioned; especially of such as belong to or resemble the genus *Sporotrichum*.

The destruction of timber by such plants is effected in part by the disintegration of the tubes of the weed, in consequence of the introduction between them of the fine filamentous spawn of the fungi, and in part by the dampness which is thus conveyed to the interior of the wood, where it soon produces decomposition. It is not, however, certain that dry rot is always caused in this manner; on the contrary, the term appears to be frequently applied to cases of spontaneous decomposition of timber without the presence of fungi, or when the appearance of the latter takes place long after the commencement of the disease.

When dry rot produced by fungi has once made its appearance, there is no means of arresting its progress without removing the whole of the diseased and neighboring parts; and even then it will probably again break out, unless means can be taken to introduce a circulation of fresh air among the parts liable to the affection. For if timber is allowed to remain in a damp situation, and in the dark, it affords so favorable a nidus for the seeds of fungi, that they are almost certain to vegetate upon it; unless some means have been previously taken to render the timber permanently unsuited to their growth. This end appears to have been attained by Mr. Kyan, who obtained a patent for pickling timber, as a preventive of the dry rot, and who employed for this purpose a solution of corrosive sublimate. This salt of mercury is a well-known vegetable poison: if any animal jelly, upon which fungi will quickly appear in the form of mouldiness, is mixed with a minute quantity of corrosive sublimate, no fungi will in that case be produced; so that both theory and experience are in favor of Mr. Kyan's process. It is not improbable that the progress of dry rot might even be arrested in the buildings where it occurs, if the timbers could be got at and well washed with the same solution.

Although dry rot generally fixes itself upon timber, it will also attack any form of vegetable matter. The paper hangings of rooms, chiefly composed of cotton and linen thread, are occasionally overrun in houses which have been long shut up and neglected; and the mildew which destroys the strength of canvas is only another form of dry rot, the appearance of which is altered by the special circumstances under which the fungus is developed, or by the species of the fungus itself. (*See* WOOD, PRESERVATION OF.)

DRYSALTER. A dealer in salted or dried meats, and in the materials used in pickling, salting, and preserving various kinds of food; hence drysalters usually sell a number of saline substances and miscellaneous drugs.

DRYSTOVE. A glazed structure for containing the plants of dry arid climates; such as the cactuses, mesembryanthemums, aloes, and other succulents of Africa.

DUCTILITY. A property of certain bodies, in consequence of which they can be *drawn out* at length without suffering any interruption of the continuity of their constituent particles. The term ductility is frequently confounded with malleability, or that property of bodies through which different forms can be given to them by pressure or percussion. In general ductility depends, in a greater or less degree, on the temperature. Some bodies—wax for example—are rendered ductile by a small degree of heat; while glass requires a violent heat before it acquires ductility. Some of the metals —for example, gold, silver, lead, &c.— are ductile under all known temperatures.

"The ductility of some metals far exceeds that of any other substance. The goldbeaters begin their operations with a riband an inch broad and 150 inches long, which had been reduced, by passing it through rollers, to about the 800th part of an inch in thickness. The riband is cut into squares, which are disposed between leaves of vellum, and beat by a heavy hammer till they acquire a breadth of about three inches, and are thus extended to ten times their former surface. These are again quartered and placed between the folds of goldbeater's skin. and stretched out by the operation of a lighter hammer to the breadth of five inches. The same process is repeated, sometimes more than once, by a succession of lighter hammers; so that 876 grains of gold are thus finally extended into 2000 leaves of 3·3 inches square, making in all 80 books, containing each of them 25 leaves. The metal is consequently reduced to the thinness of the 282,000th part of an inch, and every leaf weighs rather less than the fifth part of a grain. A particle of gold, not exceeding the 500,000th part of a grain, is hence distinctly visible to the naked eye.

"It has been asserted that wires of pure gold can be drawn of only the 4000th part of an inch in diameter; but Dr. Wollaston, by an ingenious procedure, has lately advanced much further. Taking a short cylinder of silver, about the third part of an inch in diameter, he drilled a fine hole through its axis, and inserted a wire of platinum only the 100th part of an inch thick. This silver mould was now drawn through the successive holes of a steel plate, till its diameter was brought to near the 1500th part of an inch; and consequently the internal wire, being diminished in the same proportion, was reduced to between the 4000th and 5000th part of an inch. The compound wire was then dipped in warm nitric acid, which dissolved the silver, and left untouched its core, or the wire of platinum. By passing the incrusted platinum through a greater number of holes wires still finer were obtained, some of them only the 30,000th part of an inch in diameter. The tenacity of the metal, before reaching this limit, was even considerable; a platinum wire, of the 18,000th part of an inch in diameter, supporting the weight of a grain and a third."

Glass, when well softened by the fire, becomes as ductile as soft wax, and may be spun out into threads of greater fineness than any hair, and which bend and wave like hair in the wind. The method of producing these threads is exceedingly easy. Two workmen are employed; the first holds the glass over the flame of a lamp; the second applies a hook to the metal in fusion, which, when drawn back, brings with it a thread of glass, still adhering to the mass; the hook is then fitted on the circumference of a wheel, which, being turned round, draws out the thread, and winds it about its rim. Some of these threads are scarcely larger than that of a silkworm, and are surprisingly flexible.

DUNGING. One of the processes of dyeing and calico printing. The steeping the goods in a bath of cowdung.

Experience has proved that dunging is one of the most important steps in the process of calico printing, and that if it be not well performed the dyeing is good for nothing. Before we can assign its peculiar function to the dung in this case, we must know its composition. Fresh cows' dung is commonly neutral when tested by litmus paper; but sometimes it is slightly alkaline, owing, probably, to some peculiarity in the food of the animal.

The total constituents of 100 parts of cow dung are as follows: Water, 69·58; bitter matter, 0·74; sweet substance, 0·93; chlorophylle, 0·28; albumine, 0·63; muriate of soda, 0·08; sulphate of potash, 0·05; sulphate of lime, 0·25; carbonate of lime, 0·24; phosphate of lime, 0·46; carbonate of iron, 0·09; woody fibre, 26·39; silica, 1·14; loss, 0·14.

In dunging calicoes the excess of uncombined mordant is in part attracted by the soluble matters of the cow's dung, and forms an insoluble precipitate, which has no affinity for the cloth, especially in presence of the insoluble part of the dung, which strongly attracts alumina. The most important part which that insoluble matter plays, is to seize the excess of the mordants, in proportion as they are dissolved by the water of the bath, and thus to render their reaction upon the cloth impossible. It is only in the deposite, therefore, that the matters carried off from the cloth by the dung are to be found.

M. Camille Kœchlin ascribes the action of cow dung chiefly to its albuminous constituents combining with the alumina and iron, of the acetates of these bases dissolved by the hot water of the bath. The acids consequently set free, soon become evident by the test of litmus paper, after a few pieces are passed through, and require to be got rid of either by a fresh bath, or by adding chalk to the old one. The dung thus serves also to fix the bases on the cloth, when used in moderation. It exercises likewise a disoxydating power on the iron mordant, and restores it to a state more fit to combine with coloring matter.

DWARFING TREES. Dwarf trees may be produced in three different ways: by grafting on dwarf slow-growing stocks, as, for example, the pear on the quince; by planting in pots of small size filled with poor soil, by which the plant is starved and stunted; and by causing a portion of the extremity of a branch to produce roots, and then cutting it off and planting it in a pot or box of poor soil. This last is the Chinese method, and is thus performed:—The extremity of a branch two or three feet in length, in a fruit or flower-bearing state—for example, the points of the branches of a fir tree bearing cones, or of an elm bearing blossom buds—being fixed on, a ring of bark is taken off at the point where it is desired that the roots should be produced. The space thus laid bare is covered with a ball of moist clay, which is kept moist by being covered with moss, which is occasionally watered. In the course of two or three months in some trees, and of a year or two in others, roots are protruded into the ball of clay. The branch may then be cut off below the part from whence the roots have been protruded, and the branch being planted in a pot of poor soil, and kept sparingly supplied with water, it will remain nearly in its present state for many years; producing leaves, and perhaps flowers, annually, but never shoots longer than a few lines.

DYEING. The object of this beautiful art is to fix certain coloring matters uniformly and permanently in the fibres of wool, silk, linen, cotton, and other substances. The moderns have obtained from this Continent several dye-drugs unknown to the ancients; such as cochineal, quercitron, Brazil wood, logwood, annatto; and they have discovered the art of using indigo as a dye, which the Romans knew only as a pigment. But the vast superiority of our dyes over those of former times must be ascribed principally to the employment of pure alum and solution of tin as mordants, either alone or mixed with other bases; substances which give to our common dye-stuffs remarkable depth, durability,

and lustre. Another improvement in dyeing of more recent date is the application to textile substances of metallic compounds, such as Prussian blue, chrome yellow, manganese brown, &c.

There are a few dyeing materials which impart their color to different stuffs without any previous preparation, and these have been technically termed *substantive colors;* by far the greater number, however, of coloring materials, only impart a fugitive tint under such circumstances, and require that the stuff to be dyed should undergo some previous preparation, in order to render the color permanent; that is, capable of resisting the action of air, light, and water. The substance applied with this intention is called a *base* or *mordant*, and must possess an affinity for the fibre of the stuff on the one hand, and for the coloring materials on the other. The mordant often effects another important object; that of changing or exalting the color at the same time that it fixes it. The principal mordants are aluminous earth and oxide of iron, and these are usually applied in the state of acetates. Oxide of tin is a valuable mordant; it is generally applied as nitrate or chloride. As an instance, we may mention the mode of dyeing calico red by means of *madder*, a decoction of which, if applied to the unprepared goods, would only give them a dirty red tinge, neither agreeable nor permanent. If the calico be previously passed through a weak solution of acetate of alumina, and then dried at a high temperature, and afterwards washed, a portion of the alumina is retained in chemical combination with the fibre of the calico; and when thus prepared and submitted to the action of a hot decoction of madder, and again washed, it comes out of a fine red, which is fixed in consequence of the attraction of the alumina for the peculiar principle which gives color to the madder. If the mordant be oxide of iron instead of alumina, the color which is then produced is purple; and various shades and colors are obtained by mixing mordants, by using more or less of them, and by applying the colored solutions in various states of concentration. Sometimes articles are dyed by a similar precipitation of colored metallic oxides in the fibre; thus yellow is obtained by passing cloth impregnated with acetate of lead through a solution of chromate of potash: a double decomposition ensues, and yellow chromate of lead is precipitated in and combined with the vegetable or animal fibre. Blues are produced by passing the goods previously mordanted with iron through an acidulated solution of ferrocyanate of potash; these are generally called *chemical colors*, though not in fact more so than the others. Scarlet is exclusively produced by the coloring matter either of the cochineal or of the lac insect, which is fixed by oxide of tin, or by alumina, and heightened by the action of tartar.

Indigo. This dye-drug, when tolerably good, contains half its weight of indigotine. The cold vat is prepared commonly with water, copperas, indigo, lime, or sometimes carbonate of soda, and is used almost exclusively for cotton and linen; immersion in acidulated water is occasionally had recourse to for removing a little oxyde of iron which attaches itself to the cloth dyed in this vat.

The indigo vat for wool and silk is mounted exclusively with indigo, good potashes of commerce, madder, and bran. In this vat, the immediate principles with base of carbon and hydrogen, such as the extracts of madder and bran, perform the disoxydising function of the copperas in the cold vat. The pastel vats require most skill and experience, in consequence of their complexity. The greatest difficulty occurs in keeping them in a good condition, because they vary progressively as the dyeing goes on, by the abstraction of the indigotine, and the modification of the fermentable matter employed to disoxygenate the indigo. The alkaline matter also changes by the action of the air. By the successive additions of indigo, alkali, &c., this vat becomes very difficult to manage with profit and success. The great affair of the dyer is the proper addition of lime; too much or too little being equally injurious.

Sulphate of indigo, or Saxon blue, is used also to dye silk and wool. If the wools be ill sorted, it will show their differences by the inequalities of the dye. Wool dyed in this bath put into water saturated with sulphuretted hydrogen, becomes soon colorless, owing to the disoxygenation of the indigo. The woollen cloth when exposed to the air for some time resumes its blue color, but not so intensely as before.

Logwood. The properties of hematine explain the mode of using logwood. When stuffs are dyed in the infusion or decoction of this wood, under the influence of a base which acts upon the hematine in the manner of an alkali, a blue dye, bordering upon violet, is obtained.

Such is the process for dyeing cotton and wool a logwood blue by means of verdigris, crystallized acetate of copper, and acetate of alumina.

When we dye a stuff yellow, red, or orange, we have always bright tints: with blue, we may have a very dark shade, but somewhat violet; the proper black can be obtained only by using the three colors, blue, red, and yellow in proper proportions. Hence we can explain how the tints of yellow, red, orange, blue, green, and violet, may be browned, by applying to them one or two colors which along with themselves would produce black; and also we may explain the nature of that variety of blacks and grays which seems to be indefinite. Nutgalls and sulphate of iron, so frequently employed for the black dye, give only a violet or bluish gray. The pyrolignite of iron, which contains a brown empyreumatic matter, gives to stuffs a brown tint, bordering upon greenish yellow in the pale hues, and to chestnut brown in the dark ones. By galling cotton and silk, and giving them a bath of pyrolignite of iron, we may, after some alternations, dye them black. Galls, logwood, and a salt of iron, produce merely a very deep violet blue; but by boiling and exposure to the air, the hematate of iron is changed, becoming red-brown, and favors the production of black. Galls and salts of copper dye stuffs an olive drab, logwood and salts of copper, a violet blue; hence their combination should produce a black. In using sumach as a substitute for galls, we should take into account the proportion of yellow matter it contains. When the best possible black is wanted upon wool, we must give the stuff a foundation of indigo, then pass it it into a bath of logwood, sumach, and proto-sulphate of iron. The sumach may be replaced by one third of its weight of nutgalls.

The compound or mixed colors, are such as result from the combination of two differently colored dye-stuffs, or from dyeing stuffs with one color, and then with another. The simple colors of the dyer are red, yellow, blue, and black, with which, when skillfully blended, he can produce every variety of tint. Berhaps the dun or fawn color might be added to the above, as it is directly obtained from a great many vegetable substances.

1. Red with yellow, produces orange; a color which, upon wool, is given usually with the spent scarlet bath. To this shade may be referred flame color, pomegranate, capuchin, prawn, jonquil, *cassis*, chamois, *café au lait*, aurora, marigold, orange peel, *mordorés*, cinnamon, gold, &c. Snuff, chestnut, musk, and other shades are produced by substituting walnut peels or sumach for bright yellow. If a little blue be added to orange, an olive is obtained. The only direct orange dyes are annotto, and subchromate of lead (*see* SILK AND WOOL DYEING).

2. Red with blue produces purple, violet, lilac, pigeon's neck, mallow, peach-blossom, *bleu de roi*, lint-blossom, amaranth.

3. Red with black; brown, chocolate, marone, &c.

4. Yellow with blue; green of a great variety of shades, such as nascent green, gay green, grass green, spring green, laurel green, sea green, celadon green, parrot green, cabbage green, apple green, duck green.

5. Mixtures of colors, three and three, and four and four, produce an indefinite diversity of tints; thus, red, yellow, and blue, form brown olives, and greenish grays; in which the blue dye ought always to be first given, lest the indigo vat should be soiled by other colors. Red, yellow, and gray, (which is a gradation of black), give the dead-leaf tint, as well as dark orange, snuff color, &c. Red, blue, and gray, give a vast variety of shades; as lead gray, slate gray, wood-pigeon gray, and other colors, too numerous to specify.

The following list of dyes, and the coloring substances which produce them, may prove useful.

Red. Cochineal, kermes, lac, madder, archil, carthamus or safflower, Brazil wood, logwood, periodide of mercury, alkanet.

Yellow. Quercitron, weld, fustic, (yellow wood) annotto, sawwort, dyer's broom, turmeric, fustic, (*rhus cotinus*) Persian and Avignon berries, (*rhamnus infectorius*) willow, peroxide of iron; chromate of lead, (chrome yellow) sulphuret of arsenic, hydrosulphuret of antimony; nitric acid on silk.

Blue. Indigo, woad or pastel, Prussian blue, turnsole or litmus, logwood with a salt of copper.

Black. Galls, sumach, logwood, walnut peels, and other vegetables which contain tannin and gallic acid, along with ferruginous mordants. The anacardium of India.

Green. These are produced by the blue and yellow dyes skillfully combined;

with the exception of the chrome green, and perhaps the copper green of Schweinfurt.

Orange. Annotto, and mixtures of red and yellow dyes; subchromate of lead.

Fawn, *Dun*, *Root.* Walnut peels, sumach, birch-tree, henna, sandal wood.

The chemical principles of the art of *calico printing* are the same as those of dyeing, but the details are more difficult and complicated; and in consequence of the combination of a great variety of colors upon the same ground, the process is sometimes extremely refined and intricate; so that a rich, varied, and pleasing pattern, thus effectively produced, may be considered as a triumph of practical skill over theoretical difficulties, which is scarcely rivalled, and certainly not excelled, in any other of the arts. It is obvious that calico printing is in the abstract a topical dyeing; and much discrimination and taste are requisite in the contrivance of the pattern, its general design, and the colors in which it is exhibited. In this art the mordants, and sometimes the colors, are applied either by *blocks*, upon which the pattern is designed in relief, or by *copper plates*, which are engraved, or by *cylinders* or rollers. If the aluminous mordant be printed by one block and the iron mordant by another, and the mixture of the two by a third, and the piece thus prepared be then passed through a madder bath, and properly cleansed and bleached, the color will only adhere to the mordanted places, and it will be red where the aluminous earth only has been applied, purple with the mixed mordant, and black with the iron; if the same three mordants be used with a decoction of quercitron bark, the resulting colors will be yellow, olive, and brown; and in this way a great variety of colors may be produced. Sometimes copperplate and block printing are combined; a fine running pattern being printed by the plate or cylinder over the whole surface, which serves as a ground work, and upon which other figures are printed by blocks. Sometimes the mordant and color are both applied at once by means of a block, and rendered fixed and permanent by exposing the goods for some time to steam. Beautiful effects are produced by printing the patterns on a mordanted ground with some substance which will resist the color, and so produce a white pattern on a colored ground. (*See* CALICO PRINTING.)

DYKE. In geology is a term applied to a mass of igneous rock, as granite, trap, greenstone, or lava, which is thrown up or injected through and into the rents and fissures of a stratified, or even an igneous rock. Dykes are of frequent occurrence in districts where primary rock prevails. *Dyke* is also a mound of earth or stone, or other material intended to prevent the sea inundating contiguous low coasts, such as in Holland.

DYNAMOMETER. An instrument for measuring power of any kind, as the strength of men and animals, the force of machinery, the magnifying power of a telescope, &c. An instrument for measuring animal force was invented by Mr. Graham many years ago, and afterwards improved by Desaguliers; but as it consisted of wooden works, it was too heavy and bulky to be conveniently used for ordinary purposes. Leroy, of the Academy of Sciences of Paris, proposed a dynamometer, which consisted merely of a tube of metal of ten or twelve inches in length, placed vertically on a stand, and containing a spring in its interior, which indicated by its compression the amount of the force applied. The instrument was in fact the same in principle as the common spring balance.

The most convenient dynamometer is that of Regnier, which is described in the *Journal de l'Ecole Polytechnique*. It consists of an elliptical steel spring of about 12 inches in circumference, and the force is applied either by pressing the two vertices of the axis minor against each other, or by drawing in opposite directions the two ends of the axis major. In both cases the sides of the spring are made to approach each other; and thus they move an index which marks the degree of approximation on a semicircular scale. By means of this machine the mean force is ascertained which a man can exert with the right hand, or with the left, or with both together, and in various positions of his body. Some interesting results relating to the average strength of men at different ages, and of different weights and sizes, have been deduced by M. Quetelet of Brussels, from numerous experiments with his dynamometer. In testing the value of ploughs, the dynamometer should be used, instead of ploughing a given space of land.

EARTHEN WARE. See Pottery.

EARTH. Modern science has demonstrated that the substances called primitive earths, and which prior to the great electro-chemical career of Sir H. Davy, were deemed to be elementary matter, are all compounds of certain metallic bases and oxygen, with the exception of silica, whose base, silicon, being analogous to boron, has led that compound to be regarded as an acid; a title characteristic of the part it extensively performs in neutralizing alkaline bodies, in mineral nature, and in the processes of art. Four of the earths, when pure, possess decided alkaline properties, being more or less soluble in water, having (at least three of them) an acrid alkaline taste, changing the purple infusion of red cabbage to green, most readily saturating the acids, and affording thereby neutro-saline crystals. These four are *baryta*, *strontia*, *lime*, and *magnesia*. The earths proper are five in number; *alumina*, *glucina*, *yttria*, *zirconia*, and *thorina*: These do not change the color of infusion of cabbage or tincture of litmus, do not readily neutralize acidity, and are quite insoluble in water. The alkalis are soluble in water, even when carbonated; a property which distinguishes them from the alkaline earths. *Lithia* must for this reason be considered to be an alkali. See the above substances in their alphabetical places.

EAU DE COLOGNE. This preparation has long possessed great celebrity, in consequence chiefly of the numerous virtues ascribed to it by its venders; and is resorted to by many votaries of fashion as a panacea against ailments of every kind. It is however nothing more than aromatized alcohol, and as such, an agreeable companion of the toilet. Numerous fictitious receipts have been offered for preparing *eau de Cologne*; the following may be reckoned authentic, having been imparted by Farina himself to a friend.

Take 60 gallons of silent brandy: sage, and thyme, each 6 drachms; balm-mint and spearmint, each 12 ounces; calamus aromaticus, 4 drachms; root of angelica, 2 drachms; camphor, 1 drachm; petals of roses and violets, each 4 ounces; flowers of lavender, 2 ounces; flowers of orange, 4 drachms; wormwood, 1 ounce; nutmegs, cloves, cassia lignia, mace, each 4 drachms. Two oranges and two lemons, cut in pieces. Allow the whole to macerate in the spirit during 24 hours, then distil off 40 gallons by the heat of a water bath. Add to the product:

Essence of lemons, of cedrat, of balm-mint, of lavender, each 1 ounce 4 drachms; neroli and essence of the seed of anthos, each 4 drachms; essence of jasmin, 1 ounce; of bergamot, 12 ounces. Filter and preserve for use.

Cadet de Gassincourt has proposed to prepare *eau de Cologne* by the following recipe; Take alcohol at 32° B., 2 quarts; neroli, essence of cedrat, of orange, of lemon, of bergamot, of rosemary, each 24 drops; add 2 drachms of the seeds of lesser cardamoms, distil by the heat of a water bath, a pint and a half. When prepared as thus by simple mixture of essences without distillation, it is never so good.

EAU DE LUCE is a compound formed of the distilled oil of amber and water of ammonia.

EAU DE JAVELLE. Solution of hypochlorite of soda.

EBULLITION. When the bottom of an open vessel containing water is exposed to heat, the lowest stratum of fluid immediately expands, becomes therefore specifically lighter, and is forced upwards by the superior gravity of the superincumbent colder and heavier particles. The heat is in this way diffused through the whole liquid mass, not by simple communication of that power from particle to particle as in solids, called the *conduction* of caloric, but by a translation of the several particles from the bottom to the top, and the top to the bottom, in alternate succession. This is denominated the *carrying* power of fluids, being common to both liquid and gaseous bodies. These internal movements may be rendered very conspicuous and instructive, by mingling a little powdered amber with water, contained in a tall glass cylinder, standing upon a sand-bath. A column of the heated and lighter particles will be seen ascending near the axis of the cylinder, surrounded by a hollow column of the cooler ones descending near the sides. That this molecular translation or locomotion is almost the sole mode in which fluids get heated, may be demonstrated by placing the middle of a pretty long glass tube, nearly filled with water, obliquely over an argand flame. The upper half of the liquid will soon boil, but the portion under the middle will continue cool, so that a lump of ice may remain for a considerable time at the bottom. When the heat is rapidly applied the liquid is thrown into agitation, in consequence of elastic vapor being suddenly generated at the bottom of the vessel, and being as suddenly condensed at a little distance above it by the surrounding cold columns. These alternate expansions and contractions of volume become more manifest as the liquid becomes hotter, and constitute the *simmering* vibratory sound which is the prelude of ebullition. The whole mass being now heated to a pitch compatible with its permanent elasticity, becomes turbulent and explosive under the continued influence of fire, and emitting more or less copious volumes of vapor, is said to boil. The further elevation of temperature by the influence of caloric, becomes impossible in these circumstances with almost all liquids, because the vapor carries off from them as much heat in a latent state as they are capable of receiving from the fire.

The temperature at which liquids boil in the open air varies with the degree of atmospheric pressure, being higher as that is increased, and lower as it is diminished. Hence boiling water is colder by some degrees in bad weather, or in an elevated situation, with a depressed barometer, than in fine weather, or at the bottom of a coal-pit, when the barometer is elevated. A high column of liquid, also, by resisting the discharge of steam, raises the boiling point. In *vacuo*, all liquids boil at a temperature about 124° F. lower than under the average atmospheric pressure.

The following is a table of the boiling points of a few substances, on Fahrenheit's scale:

Ether,	100°	Alcohol,	173°
Nitric Acid,	210°	Water,	212°
Solution of Salt,	224°	Chloride of Calcium,	285°
Muriatic Acid,	222°		
Oil of Turpentine,	315°	Sulphuric Acid,	600°
Phosphorus,	554°	Sulphur,	570°
Linseed Oil,	640°	Mercury,	662°

M. Marcet has shown, that whatever the nature of the boiler, the temperature of the steam is invariably lower than that of the water from which the steam is generated. In glass vessels, this difference amounts, on an average, to 1,908 degrees,—in metal vessels, only to between 0.27 and 0.36 of a degree. There is but one exception to this rule, viz: where the inside of the boiler is coated with a thin layer of sulphur, gum lac, or any other matter possessing an adhesion for water. In that case the boiling water and the steam have the same temperature. Thus, contrary to the generally received notion, it is not in metal vessels that the boiling point is lower under a stronger pressure, but in glass vessels; if the latter are coated with sulphur, gum lac, &c.

EDULCORATION. A chemical term applied to the cleansing of substances, especially pulverulent precipitates, by the repeated affusion of water, so as to remove all soluble matters, and render them free from taste and smell.

EFFERVESCENCE. The escape of gaseous matter from liquids, as in the act of fermentation. All liquids from which bubbles of gas rapidly escape, so as to resemble boiling, are said to effervesce.

EFFLORESCENCE. Is the spontaneous conversion of a solid, usually crystalline, into a powder, in consequence either of the abstraction of the combined water by the air, as happens to the crystals of sulphate and carbonate of soda; or by the absorption of oxygen and the formation of a saline compound, as in the case of alum schist, and iron pyrites. Saltpetre appears as an efflorescence upon the ground and walls in many situations.

EDGE-TOOLS. (*See* CUTLERY and STEEL.)

EGG. The ovum of birds and other oviparous animals. The changes which the hen's egg undergoes during incubation have been described by Sir E. Home in the *Philosophical Transactions* for the year 1822, page 339, and illustrated by a beautiful series of plates after Bauer's drawings; the same volume also contains a valuable paper by Dr. Prout on the same subject, but chiefly in reference to the chemical changes of the egg during that process. The specific gravity of new-laid eggs at first rather exceeds that of water, varying from 1080 to 1090; but they soon become lighter, and swim on water, in consequence of evaporation through the pores of the shell. When an egg is boiled in water and suffered to cool in the air, it looses about 32 hundredths of a grain of saline matter, together with a trace of animal matter and free alkali. The mean weight of a hen's egg is about 875 grains, of which the shell and its inner membrane, weigh 93·7 grains, the *albumen*, or white, 529·8 grs., and the yolk 251·8 grs. The shell contains about 2 *per cent.* of animal matter and 1 *per cent.* of the phosphates of lime and magnesia, the remainder being carbonate of lime, with a trace of carbonate of magnesia. When the yolk of a hard-boiled egg is digested in repeated portions of strong alcohol, there remains a white residue having the leading characters of albumen, but containing phosphorus in some peculiar state of combination; the alcoholic solution is yellow, and deposits a crystalline fatty matter, and when distilled leaves a yellow oil. The albumen of the egg contains sulphur. The use of the phosphorus is to yield phosphoric acid to form the bones of the chick; but the source of the lime with which it is combined is not apparent, for it has not been detected in the soft parts of the egg, and hitherto no vascular communication has been discovered between the chick and the shell.

EGGS, HATCHING. (*See* Incubation, Artificial.)

EIDER-DOWN is a kind of precious down, so called because it is obtained from the *Eider*-duck. These birds build their nests among precipitous rocks, and the female lines them with fine feathers plucked from her breast, among which she lays her five eggs. The natives of the districts frequented by the eider-ducks let themselves down by cords among the dangerous cliffs, to collect the down from the nests. It is used to fill coverlets, pillows, cushions, &c.

ELAINE is the name given by Chevreul to the thin oil which may be expelled from tallow, and other fats, solid or fluid, by pressure either in their natural state, or after being saponified, so as to harden the *stearine*. It may be extracted also by digesting the fat in 7 or 8 times its weight of boiling alcohol, spec. grav. 0·798, till it dissolves the whole. Upon cooling the solution, the stearine falls to the bottom, while the elaine collects in a layer like olive oil, upon the surface of the supernatant solution, reduced by evaporation to one-eighth of its bulk. If this elaine be now exposed to a cold temperature, it will deposit its remaining stearine and become pure. See Fat, Oils, and Stearine.

ELASTICITY. In Physics, that property which certain bodies possess of recovering their primitive form and dimensions after the external force by which they have been dilated or compressed or bent is withdrawn.

The theory of elasticity must be deducted from some hypothesis respecting the constitution of matter. The simplest and most general view which can be taken of the subject is, that all matter is composed of indefinitely small parts or *molecules* acted upon by attractive and repulsive forces. The attractive forces result from the action of the molecules on each other; the repulsive forces from the caloric with which the molecules are combined. From the combined action of these two forces, the attraction of matter and the repulsion of caloric, the different forms of matter and its varied physical properties may be explained.

This view of the constitution of bodies supposes that the molecules are not in contact, but at a certain distance from each other, which, though it is to be regarded as indefinitely small in comparison of any distance appreciable by our senses, admits nevertheless of increase and diminution. When a body is in a state of rest, the opposite forces which any two of its contiguous molecules exercise on each other are in equilibrium. The energy of the forces also depends on the distance between the two molecules, or, in mathematical language, is a function of that distance. If the distance be increased within the limits of the action of the forces, both forces are diminished; and if the distance is diminished, both are increased, but not in the same proportion. If the interval at which the two forces balance each other be diminished, the repulsive force becomes stronger than the attractive force, and the two molecules are repelled from each other; on the contrary, if the distance be increased, the attractive force acquires the superiority, and the molecules are drawn towards each other.

Elasticity is perfect when the body exactly recovers its primitive form, after the force by which it is bent or compressed or dilated has been removed, in the same time as was required for the force to produce the alteration. This perfect elasticity is, however, not found in any of the bodies of nature; the aëriform fluids or gases are those whose elasticity approaches the nearest to it. Hard bodies, even tempered steel and ivory, possess it in a less degree; in fluid substances the elastic force is greatly diminished; and in soft bodies, as butter, moist clay, it entirely disappears. In solid bodies the elastic force is, in general diminished by use, or by a long continued application of a straining force. A bow which has been long bent, or a spring which has been long compressed, will not entirely recover its original form. In many cases the elasticity of a body can be augmented by producing a closer aggregation of the molecules. The metals, for example, are rendered more elastic by hammering them cold, or by alloys. Iron and steel acquire a greater elasticity by *tempering*; that is, by producing a sudden contraction of their volumes when they have been expanded by heat.

The principal phenomena of elastic bodies are the following:—1, That an elastic body (the elasticity being supposed perfect) exerts the same force in endeavoring to restore itself, as that with which it was compressed or bent. 2, The force of elastic bodies is exerted equally in all directions, but the effect chiefly takes place on the side on which the resistance is the least. 3, When an elastic solid body is made to vibrate by a sudden stroke, the vibrations are performed in equal times, to whatever part of the body the stroke may be communicated. Thus, sonorous bodies always emit sounds of the same pitch; and the difference of the pitch depends on the greater or less frequency of the vibrations of the sonorous body. 4, A body perfectly incompressible cannot be elastic, therefore bodies perfectly solid can have no elasticity; and hence, also, the small degree of elasticity belonging to the liquids which are eminently incompressible.

ELASTIC BANDS. The manufacture of braces and garters, with threads of caoutchouc, either naked or covered, seems to have originated, some time ago, in Vienna, whence it was a few years since imported into Paris, and thence into this country. At first the pear-shaped bottle of Indian rubber was cut into long, narrow strips by the scissors; a single operative turning off only about 100 yards in a day, by cutting the pear in a spiral direction. He succeeded next in separating with a pair of pincers the several layers of which the bottle was composed. Another mode of obtaining fine threads was to cut them out of a bottle which had been rendered thin by inflation with a forcing pump. All these operations are facilitated by previously steeping the caoutchouc in boiling water, in its moderately inflated state. More recently, machines have been successfully employed for cutting out these filaments; but for this purpose the bottle of caoutchouc is transformed into a disc of equal thickness in all its parts, and perfectly circular. This preliminary operation is executed as follows: 1st, the bottle, softened in hot water, is squeezed between the two plates of a press, the neck having been removed beforehand, as useless in this point of view; 2d, the bottle is then cut into two equal parts, and is allowed to consolidate by cooling before subjecting it to the cutting instrument. When the bottle is strong enough, and of variable thickness in its different points, each half is submitted to powerful pressure in a very strong cylindrical mould of metal, into which a metallic plunger descends, which forces the caoutchouc to take the form of a flat cylinder with a circular base. This mould is plunged into hot water during the compression. A stem or rod of iron, which goes across the hollow mould and piston, retains the latter in its place, notwithstanding the resilience of the caoutchouc, when the mould is taken from the press. The mould being then cooled in water, the caoutchouc is withdrawn.

The transformation of the disc of caoutchouc into fine threads is performed by two machines; the first of which cuts it into a riband of equal thickness in its whole extent, running in a spiral direction from the circumference to the centre; the second subdivides this riband lengthwise into several parallel filaments much narrower, but equally thick.

The threads, when brought to this state of slenderness, are put successively into tubs filled with cold water; they are next softened in hot water, and elongated as much as possible in the following manner:—They are wound upon a reel turned quickly, while the operative stretches the caoutchouc thread with his hand. In this way it is rendered 8 or 10 times longer. The reels when thus filled are placed during some days in a cold apartment, where the threads become firm, and seem to change their nature.

This state of stiffness is essential for the success of the subsequent operations. The threads are commonly covered with a sheath of silk, cotton, or linen, by a braiding machine, and are then placed as warp in a loom, in order to form a narrow web for braces, garters, &c. If the gum were to exercise its elasticity during this operation, the different threads would be lengthened and shortened in an irregular manner, so as to form a puckered tissue. It is requisite therefore to weave the threads in their rigid and inextensible, or at least incontractile condition, and after the fabric is woven to restore to the threads of caoutchouc their appropriate elasticity. This restoration is easily effected by passing a hot smoothing iron over the tissue laid smoothly upon a table covered with blanket stuff.

ELECTIVE AFFINITY, denotes the order of preference, so to speak, in which the several chemical substances *choose* to combine; or really, the gradation of attractive force infused by Almighty Wisdom among the different objects of nature, which determines perfect uniformity and identity in their compounds amidst indefinite variety of combination. The discussion of this interesting subject belongs to pure chemistry.

ELECTRICAL WAVES, VELOCITY OF.

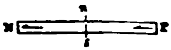
Some ingenious experiments have been performed at the Cincinnati Observatory, in connection with the magnetic telegraph, to ascertain if there be any sensible time occupied in the transmission of the wave or current of electricity between the two points where relative longitudes are required. If there be a sensible velocity, it must involve a correction for the difference of longitude as determined by star signals passed along the waves or through the ground by electrical currents between the two observatories. Thus far, Professor Mitchell says, all results tend to the conclusion that there is no sensible wave time. Other methods may lead to a different conclusion. Experiments performed some months since, by Mr. Walker, lead that gentleman to believe he had detected and measured a wave time. The subject is interesting, and now becomes important as an element in the determination of longitudes by the magnetic telegraph.

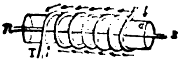
ELECTRIC CLOCK. The first public clock of this kind in the United States was placed above the chief entry of the Bank of Louisiana, New Orleans. It is a beautiful object to look at from the street, but there is something still more interesting connected with it. This consists of the method employed for setting the hands in motion, which is by electricity.

At the Bank of Louisiana there is nothing but the dial and the hour and minute hands; the clock is in Mr. Foster's store, where also is the galvanic pile from which the conducting wire leads to the Bank, past the adjoining houses, and along which the electric current travels that moves the hands. A person standing in the street can see both by day and by night the progress of the minute hand, which moves every half minute. (*See* CHRONOGRAPH.)

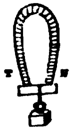
ELECTRO-MAGNETISM. When a current of electricity is traversing any substance, or when electricity is in motion magnetism is at the same time developed. This fact was first observed by Professor Oersted, of Copenhagen, and has become the source of an important series of discoveries included under the above term. The excitation of magnetism depends upon *quantity* of electricity, and is best observed in the wire which closes the voltaic circle, especially of one or more pairs of large plates. If a magnetic needle be brought near a wire through which an electric current is passing, it will immediately deviate from its usual position, and assume a new one, dependent upon the relative position of the needle and the wire. On placing the electric wire *above* and parallel to the magnet, the pole next the negative end of the battery always moves to the west; and when the wire is placed *under* the needle, the same pole turns to the east. When the electric wire is on the same horizontal plane with the needle, no declination takes place; but the magnet shows a disposition to move in a vertical direction, the pole next the negative side of the battery being depressed when the wire is to the west of it, and elevated when it is to the east.

The magnetic phenomena of a wire transmitting electricity are such as appear to depend upon the circulation of magnetism at right angles to the electric current, so that if N P represent the wire transmitting a current of electricity in the direction of the horizontal darts, a current of magnetism will be established in the direction of the vertical dart, appearing to move round the axis of the electric current; hence the term *vertiginous* or rotary magnetism, applied to these phenomena: and hence the motion of the pole of the magnet round the electric wire, or of the electric wire round the pole of the magnet, when they respectively are so arranged as to be able to move freely in any direction. If a steel needle be placed in contact with the electric wire, and parallel to it, it acquires opposite magnetisms upon its two sides; but if it be placed at right angles to the connecting wire, it becomes polar, and permanently magnetic. If the electric wire be twisted into a spiral, and the steel needle placed within it (as in the cut), it is retained there, and becomes a more powerful magnet in consequence of the repetitions and direction of the electric and magnetic currents, as will be evident from the annexed figure, where *a* represents a glass tube with the wire T conveying the electric current twisted round it; the darts at the ends of which show the ingress and egress of the electricity, and the transverse darts the direction of the magnetic current. If the cylinder round which the wire conveying the electric current is twisted be of steel, it becomes a permanent mag-





net; if of pure soft iron, it becomes a temporary magnet, so long as the electric current is in motion, and *s* and *n* are powerfully opposed poles. If the bar be bent, as in the annexed cut, a powerful horse-shoe magnet is obtained when the ends *t* *n* of the copper wire twisted round it are connected with the voltaic circle; and a single pair of plates is sufficient for the purpose.



ELECTRO-MAGNETIC ORE SEPARATOR. Mr. Ransom Cook has patented a machine for separating the magnetic iron from the rock with which it is associated. He employs a revolving cylinder or drum with electro-magnetic poles on its circumference. When the crushed ore passes underneath the revolving cylinder, the oxide of iron is attracted to the cylinder, leaving the impurities behind: when the drum is charged with ore, the cylinder is freed from connection with the battery, and the ore then losing its attractive force, drops off into the receiving-box.

ELECTRO-MAGNETISM. (MOTIVE POWER OF.) Numerous attempts have been made to apply electro-magnetism as a power for moving machines, and particularly by the apparatus employed by Jacobi, Dal Negro, M'Gauley, Wheatstone, and the machines recently constructed by Mr. Hjorth. However, notwithstanding the talent which has been devoted to this interesting subject, and the large amount of money which has been spent in the construction of machines, the public are not yet in possession of any electro-magnetic machine which is capable of exerting power economically.

The most remarkable experiments are those of Professor Jacobi, who, in 1838 and '39, succeeded in propelling a boat upon the Neva at the rate of four miles an hour.

Mr. Hjorth's engine embraces many new features that promise to render the power more effective than hitherto. One of the electro-magnets made for the large engine, in a recent trial, supported nearly 5000 lbs., and its attractive force at ¼ of an inch was equal to nearly 1500 lbs. As this force can be multiplied without limits, it is reduced to a question of economy and convenience.

The power of electro-magnets can be increased without limitation. A voltaic current produced by the chemical disturbance of the elements of any battery no matter what its form may be, is capable of producing by induction a magnetic force, this magnetic force being always in an exact ratio to the amount of matter (zinc, iron, or otherwise) consumed in the battery.

The greatest amount of magnetic force is produced when the chemical action is most rapid.

Hence, in all machines, it is more economical to employ a battery of intense action, than one in which the chemical action is slow. It has been proved by Mr. Joule, and most satisfactorily confirmed by Mr. R. Hunt, that one-horse power is obtainable in an electro-magnetic engine, the most favorably constructed to prevent loss of power, at the cost of 45 lbs. of zinc, in a Grove's battery, in 24 hours, while 15 lbs. are consumed in the same time to produce the same power in a battery of Daniell's construction. The intensity of Daniell's battery being ⅓ that of Grove's. The cause of this was referred to the necessity of producing a high degree of excitement, to overcome the resistance which the molecular forces offer to the electrical perturbations, on which the magnetic force depends.

What amount of magnetic power can be obtained from an equivalent of any material consumed? The following, regarded as the most satisfactory results yet obtained:—1. The force of voltaic current being equal to 673, the number of grains of zinc destroyed per hour was 151, which raised 9000 lbs. one foot high in that time. 2. The force of current being, relatively, 1300, the zinc destroyed in an hour was 291 grains, which raised 10,030 lbs. through the space of one foot. 3. The force being 1000, the zinc consumed was 223 grains; the weight lifting one foot 12,672 lbs. The estimations made by Messrs. Scoresby and Joule, and the results obtained by Oersted, and more recently by Mr. Hunt, very nearly agree; and it was stated that one grain of coal consumed in the furnace of a Cornish engine lifted 143 lbs. one foot high, whereas one grain of zinc consumed in the battery lifted only 80 lbs. The cost of 1 cwt. of coal is under 9d.; the cost of 1 cwt. of zinc is above 216d. Therefore, under the most perfect conditions, magnetic power must be nearly 25 times more expensive than steam power. But the author proceeded to show that it was almost proved to be an impossibility ever to reach this, owing, in the first place, to the rate with which the force diminishes through space. As the mean of a great many experiments on a large variety of magnets, of different forms and modes of construction, the following result was given:

		lbs.
Magnet and armature in contact, lifting force	- - - -	220
"	distant 1-250 of an inch	90 6
"	" 1-125 "	50 7
"	" 1-68 "	50 1
"	" 1-50 "	40 5

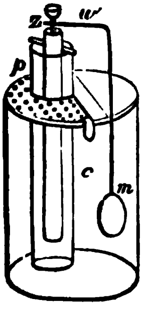
Thus at one-fiftieth of an inch distance four-fifths of the power is lost. This great reduction of power takes place when the magnets are stationary. Mr. R. Hunt has also shown that the moment they were set in motion a great reduction of the original power immediately took place; that, indeed, any disturbance produced near the poles of a magnet diminished, during the continuance of the motion, its attractive force. The attractive force of a magnet being 150 lbs. when free of disturbance, fell to one-half, by occasioning an armature to revolve near its poles. Therefore, when a system of magnets which had been constructed to produce a given power is set in revolution, every magnet at once suffers an immense loss of power, and consequently their combined action falls in practice very far short of their estimated power. This fact has not been before distinctly stated, although it is well known that Jacobi observed it. And not merely does each magnet thus sustain an actual loss of power, but the power thus lost is converted into a new form of force, or or rather becomes a current of electricity, acting in opposition to the primary current by which the magnetism is induced. From an examination of all these results, Mr. Hunt is disposed to regard electro-magnetic power as impracticable, on account of its cost, which must necessarily be, he conceives, under the best conditions, fifty times more expensive than steam power, and is at present at least 150 times as expensive.

On the other hand, in opposition to the foregoing conclusions, Professor Page, of Washington, has constructed a machine either for locomotion or stationary work. He has exhibited it in the Smithsonian Institute, and a Washington paper thus describes the circumstance:

"He then exhibited his engine, of between four and five horse power, operated by a battery within the space of three cubic feet. It looked very unlike a magnetic machine. It was a reciprocating engine of two feet stroke, and the whole battery and engine weighed about one ton. When the power was thrown on by the motion of a lever, the engine started off magnificently, making one hundred and fourteen strokes per minute; though when it drove a circular saw ten inches in diameter, sawing up boards an inch and a quarter thick into laths, the engine made but about eighty strokes per minute. There was great anxiety on the part of the spectators to obtain specimens of these laths, to preserve as trophies of this great mechanical triumph. The force operating upon his magnetic cylinder throughout the whole motion of two feet, was stated to be six hundred pounds when the engine was moving very slowly, but he had not been able to ascertain what the force was when the engine was running at a working speed, though it was considerably less. The most important and interesting point, however, is the expense of the power. Professor Page stated that he had reduced the cost so far, that it was less than steam under many and most conditions, though not so low as the cheapest steam engines. With all the imperfections of the engine, the consumption of three pounds of zinc per day would produce one horse power. The larger his engines (contrary to what has been known before), the greater the economy. Professor Page was himself surprised at the result. There were yet practical difficulties to be overcome; the battery had yet to be improved: and it remained to try the experiment on a grander scale, to make a power of one hundred horse, or more. (*See* LOCOMOTIVE.)

ELECTRO METALLURGY. By this elegant art the most exact copies of any natural or artificial object can be obtained, or the surface of any body non-metallic or metal may become coated with a thin layer or film of copper, gold, and silver, or a few other metals. The practical details of the arrangement is all that can find a space in these pages.

On the Forms and Arrangement of Apparatus.—In the deposition of metals where voltaic electricity is the power employed, there are two descriptions of arrangement: the first where the surface on which the deposit is formed is itself a part of the apparatus whence the power is generated; the other in which the object receiving the deposit forms no part of the apparatus, but where the power is procured from a battery; the former is termed the single cell, the latter the battery process. The forms of voltaic batteries used are numerous, and in most cases known by the names of their respective inventors; such as Daniell's, Smee's, and Grove's batteries. The constant battery of Professor Daniell will be found most generally useful; it is termed *constant* from its possessing the power of continuing in action for any lengthened period: it may be made in various forms, and consists of a copper cell, divided into two parts by a porous diaphragm or partition, which may be formed of wood, paper, plaster of Paris, earthenware, or animal membrane. The outer cell is filled with a saturated solution of sulphate of copper, a perforated shelf supplied with crystals of this salt is placed at the upper portion, as that part of the solution is soonest weakened, the specific gravity retaining the stronger portion below. The inner cell is filled with water, to which a few drops of sulphuric acid are added, and in which a rod or plate of amalgamated zinc is placed, to which, and to the copper of the outer cell, wires are attached. This battery may be generally employed for the purposes of plating, gilding, and platinizing, and is one of the most economical modes of reducing copper. The simplest form of apparatus used for the deposition of metal, more particularly copper, is the single cell; it resembles in the number of its parts a Daniell's battery; the surface to be deposited on representing the copper of the outer cell. The diaphragm may be formed of plaster of Paris, brown paper, or thin wood; but the action is almost rapid when the diaphragm is thinnest; if a mould of metal or other substance be attached to the zinc in the cell containing the acid and water, and introduced into the sulphate solution, if the metallic communication between the mould and the zinc be complete, after a short immersion the former will become coated with a deposition of metallic copper, which goes on increasing in thickness as long as the strength of the cupreous solution is kept up, which may be done by placing a few crystals of sulphate in the solution. Within a few months past, magneto-electric machines have been employed for the deposition of metals; and in Birmingham, plating is carried on to a considerable extent by machines, formed by peculiar arrangements of compound magnets, one of which, lately manufactured by Mr. Woolrich, is capable of depositing from 300 to 500 ounces of silver per week; but as such machines are difficult in management, and expensive in construction, they are not well suited for the purposes of experiment.



On the production of Moulds.—Moulds may be formed either of metallic or non-metallic substances; in the latter case it is absolutely necessary that the surface of the mould submitted for deposition should be a conductor of electricity, and the best conductors are metals and carbon. Moulds for small objects, as coins or medals, may readily be made of lead or fusible metal: a very simple plan is to place the object between two strips of the former metal, scraped perfectly clean, subjecting the whole to the action of a press. Moulds may be formed of wax, stearine, tallow, plaster of Paris, sealing wax, &c., &c.: the surfaces of either of these materials may be covered with good plumbago, after fixing a metal wire into the mould to be deposited on; the powder should be rubbed lightly over with a soft brush, taking care that it adheres to all parts. The deposition takes place at the wire by which the article is connected with the battery or cell, and spreads gradually from that point till the whole surface is covered; but this process is limited to the deposition of copper only, as gold and silver will not spread to any extent on a black-leaded surface. Wood may be prepared to receive a deposit in the following manner:—The surface of the block or piece intended to be deposited on is dipped in a weak solution of nitrate of silver, contained in a flat vessel, remaining for a few minutes in order that by capillary attraction the nitrate of silver may be drawn into the wood: a small portion of a solution of phosphorus in spirits of turpentine being poured into a watch-glass, and placed on a sand-bath, is allowed gradually to evaporate; on holding the surface of the wood over the vapor an immediate change occurs, the nitrate of silver is converted into metallic silver, and the object may at once be placed in the battery to receive a deposit of copper. In this manner the interior of a plaster mould may be rendered a conductor; but as this plan can only be adopted with substances which can be wetted with the solution of nitrate of silver, an improvement has lately been introduced, by the adoption of a solution of phosphorus instead of the vapor of that substance. The best known solution is bisulphuret of carbon, which easily dissolves a considerable portion of phosphorus.

If the article to be coated is dipped for a moment in a solution of one part of phosphorus to twelve parts of bisulphuret of carbon, on withdrawing it the bisulphuret of carbon, which is very volatile, will evaporate, leaving a film of phosphorus on the surface; the article is then immersed in a dilute solution of nitrate of silver, or sulphate of copper; a precipitate of silver or copper is immediately formed, and thus becoming an electric conductor it may be introduced into the galvanic cell, and the process will proceed in the same manner as it does when plumbago is used in the first instance. By this simple and elegant method the most delicate articles, as feathers, flowers, fruit, insects, &c., may be coated with metal. The surface should in all cases be free from moisture before it is introduced into the solution of phosphorus, which should be used with the greatest care, being highly inflammable. Phosphorus added to wax and stearine form an excellent coating for casts, as the surface becomes a conductor. Moulds of plaster of Paris being very porous, require to be saturated with wax, oil, varnish, or tallow, before receiving a coating of plumbago, otherwise when placed in the solution they will absorb the liquid, and the air which previously filled up the pores will be driven out, covering the surface of the mould with small bubbles. Flexible moulds for copying objects which are undercut, or overhung, may be made of a mixture of glue and treacle; this mixture is easily removed from the projecting parts, immediately regaining its proper form.

The color of bronze is given to copper articles deposited by voltaic action by different methods. A very simple plan is to rub the article with plumbago immediately, or as soon as practicable, after its removal from the battery; afterwards heating it, and rubbing it with a hard brush. A lighter tint may be obtained by covering the surface with oxide of iron, and giving it a considerable heat. Hydrosulphate of ammonia produces a fine color, and a dilute solution of chloride of platinum gives the object an agreeable tint.

On Electro-Gilding, Plating, Platinizing.—The metals reduceable by voltaic agency for purposes of utility are gold, silver, platinum, copper and zinc; these may be precipitated from their salts, or from the solutions of their salts in any material capable of dissolving them, and any desired deposit may be made by adjusting the strength and temperature of the solution to the intensity and power of the current of electricity employed. Gold may be deposited from its chloride, bromide, cyanide, iodide, sulphite, and hyposulphite; but for all purposes of gilding, it is well to use a solution of the cyanide, which may be prepared by adding oxide of gold to the solution of cyanide of potassium. The most eligible proportions may be stated as follows: Two pounds of cyanide of potassium dissolved in one gallon of water, to which are added one ounce and a half of oxide of gold; but if heat is employed, and the solution is raised to the boiling point, the quantity of water may be doubled. A single pint battery of Daniell's possesses sufficient intensity to gild any specimen, even large ones—the articles tc be gilt must of course be attached to the zinc of the battery, and a plate of gold, of corresponding or greater dimensions, to the copper. The surfaces of all objects to be gilt, plated, or deposited on, must be thoroughly cleansed before being introduced into the solution; oxide, grease, or other impurities, may be removed by immersion in dilute sulphuric acid. The gold thus deposited may be colored to produce the red tint so generally admired, by being coated with a mixture of acetate of copper, sulphate of alumina, and bees'-wax, and exposed to heat till the whole is consumed; and a rich orange color may be obtained by gently boiling the following ingredients together in water till they have a creamy consistency:—Five parts of nitrate of potassa, two parts of sulphate of alumina, one part of sulphate of zinc, and one part of sulphate of iron. The gilt object should then be dipped three or four times in the composition, and allowed to become nearly dry, and afterwards removed to a stove, when, according to the length of exposure to heat the depth of color will be increased: it should finally be well washed, and cleaned with soap and water and a brush.

Silver can be precipitated from its cyanide, acetate, sulphate, sulphite, or hyposulphite solutions. A solution of one pound and a half of cyanide of potassium in one gallon of water, to which two ounces of oxide of silver are added, answers admirably for all purposes of plating. For some time after the introduction of electro-gilding and plating, complaints were made of defective adhesion between the original and the deposited metal, and it was asserted by the manufacturers of similar articles on the old principle, that such plating and gilding would soon wear away, and exhibit the baser metal in all its original nakedness. There was, it must be admitted, some justice in this remark, though articles plated three years ago have been in daily use without showing any traces of the copper beneath. This defect was occasioned by the absence of an alloy, but the objection has lately been altogether removed by the use of mercury, for the purpose of alloying the two metallic surfaces; for this purpose, nitrate of mercury is dissolved in water, and the copper article to be gilt or plated is plunged in the solution, and immediately withdrawn, then washed in water, and placed in the gold or silver solution. A thin film of mercury is by this means distributed over the object, and amalgamating with both metals, completely alloys them. The articles after being gilt or silvered should be heated to 600° Fahr., which dissipates the mercury. Another complaint against electro-plating was, that the articles rapidly tarnished on account of the purity of the metal deposited. This may be obviated by brushing them over after removal from the vat with a saturated solution of biborate of soda, allowing them to dry so that a film of the salt may remain, repeating the process a second or third time, till a slight but regular coating of borax covers every part; they should then be exposed to a red heat, and after being allowed to cool, immersed in dilute sulphuric acid, and dried in heated saw-dust. The metals to which plating are most applicable are copper, brass, pewter, iron, steel, and gold; the process is also extensively employed for silvering articles formed of the alloy of nickel, known as German silver.

Platinum may be reduced from solutions of its bromide, iodide, and bi-chloride, and the double chloride of platinum and sodium. The chloride is the salt commonly employed, but as considerable difficulty exists in depositing this metal in a ductile state, a very feeble current of electricity should be employed, and the plate of metal introduced as an electrode should be very small; it is of great advantage to have the solution neutral, and some therefore recommend soda being added to it, thus forming the chloride of sodium and platinum.

Zinc may be deposited from its iodide, acetate, sulphate, and chloride; also from the solution of oxide of zinc in potassa, or muriate of ammonia.

Copper may be thrown down from a considerable range of its salts; those commonly used are the sulphate, nitrate, and cyanide.

Probably the most enormous application of the electrotype art is made in the sculpture of the Cathedral of St. Isaac in Petersburgh. Seven doors of the cathedral are of bronze and electrotype, the framework being of the former and the scultured posts of the latter. Three of these doors are 30 feet high and 44 feet wide, the four others 17 feet 8 inches wide. They contain 51 bas reliefs, 68 statuettes, and 84 alto relievo busts of religious subjects. The gilding of the cathedral was also done by this process. The quantity of metal employed in the dome was as follows:—Ducat gold, 247 lbs.; copper, 52¼ tons; brass, 321½ tons; wrought iron, 524¼ tons; cast iron, 1068 tons; total, 1,966¼ tons. Casts in copper have been taken from the daguerreotype plate, and impressions from these casts produced by electrotype by Dr. Paterson of Glasgow, Scotland. Smooth as a daguerreotype appears, the cast taken serves as a mould from which almost any number of impressions may be taken, which are as bold and as clear as the original type.

ELEMI is a resin which exudes from incisions made during dry weather through the bark of the *amyris elimifera*, a tree which grows in South America and Brazil. It comes to us in yellow, tender, transparent lumps, which readily soften by the heat of the hand. They have a strong aromatic odor, a hot spicy taste, and contain 12¼ per cent. of ethereal oil. The crystalline resin of elemi has been called *Élemine*. It is used in making lacker, to give toughness to the varnish.

ELEMENTS. The ancients considered fire, air, water, and earth, as simple substances, essential to the constitution of all terrestrial beings. This hypothesis, evidently incompatible with modern chemical discovery, may be supposed to correspond, however, to the four states in which matter seems to exist; namely, 1st, the uncontinable powers of fluids—caloric, light, electricity; 2d, ponderable gases, or elastic fluids; 3d, liquids; 4th, solids. The three elements of the alchemists, salt, earth, mercury, were, in *their* sense of the word, mere phantasms.

EMBALMING. A process adopted by the ancient Egyptians, chiefly for the preservation of dead bodies from putrefaction. The term is derived from the use of balsamic substances in the operation; in addition to these, saline substances and tanning materials seem also to have been used.

EMBANKMENT. In territorial improvement, an embankment is a mound of earth or a wall, or a structure composed partly of a wall or partly of a bank of earth, to protect lands from being overflown by rivers or the sea. Embankments appear to have been coeval with the culture of corn crops; because these, it appears, were first grown on the alluvial soils which border large rivers, and to protect the crops from the overflowing of these rivers after heavy or long-continued rains, the cultivator would naturally throw up a bank of earth. This appears to have been done in Egypt at the most remote period of which there is any record. In modern times, embankments are employed, not merely to protect land under cultivation, but to enclose land that is occasionally overflown by rivers or the sea, and render it fit for the purposes of husbandry. This has been done to a greater extent in Holland than in any other country. There are also immense embankments in Italy, particularly in Lombardy. In Britain, there are the embankments of the Thames near London, which have been in existence since the time of the Romans; many in Lincolnshire, formed during the time of Cromwell, and some of them many centuries before; and one of the most recent is that at Tre Madoc in Caernarvonshire, by which upwards of 4000 acres were recovered from spring tides, and in great part rendered fit for the plough. Embankments are attended with immense expense; but as the soil gained or protected is generally of the best quality, a judicious embankment is commonly considered as paying about the same rate of interest as a landed estate. The levees of the Mississippi are numerous examples.

EMBOSSING WOOD. Raised figures upon wood, such as are employed in picture-frames and other articles of ornamental cabinet work, are usually produced by means of carving, or by casting the pattern in plaster of Paris, or other composition, and cementing, or otherwise fixing it on the surface of the wood. The former mode is expensive; the latter is inapplicable on many occasions. The invention of Mr. Streaker may be used either by itself, or in aid of carving, and depends on the fact, that if a depression be made by a blunt instrument on the surface of the wood, such depressed part will again rise to its original level by subsequent immersion in the water.

The wood to be ornamented having been first worked out to its proposed shape, is in a state to receive the drawing of the pattern; this being put on, a blunt steel tool, or burnisher, or die, is to be applied successively to all those parts of the pattern intended to be in relief, and, at the same time, is to be driven very cautiously, without breaking the grain of the wood, till the depth of the depression is equal to the intended prominence of the figures. The ground is then to be reduced by planing or filing to the level of the depressed part; after which, the piece of wood being placed in water, either hot or cold, the part previously depressed will rise to its former height, and will then form an embossed pattern, which may be finished by the usual operations of carving.

EMBROIDERY. The name given to the art of working figures on stuffs or muslins with a needle and thread. All embroidery may be divided into two sorts, embroidery on *stuffs* and on *muslin:* the former is used chiefly in church vestments, housings, standards, articles of furniture, &c., and is executed with silk, cotton, wool, gold and silver threads, and sometimes ornamented with spangles, real or mock pearls, precious or imitation stones, &c.; the latter is employed mostly in articles of female apparel, as caps, collars, &c., and is performed only with cotton. In Germany this division is indicated by the expression *weisse* (*white* or muslin), and *bunte Stickerei* (*colored* or cloth) *embroidery.* The embroidery of *stuffs* is performed on a kind of loom or frame; that of *muslin* by stretching it on a pattern already designed. The modes of embroidering stuffs or muslin with the common needle are extremely various; but a minute description of these processes would be as difficult as it would be uninteresting to the general reader. They consist for the most part of a combination of ordinary stitches; but no limit can be assigned to their number or variety. The art of embroidery was well known to the ancients. As early as the time of Moses we find it practised successfully by the Hebrews; and long before the Trojan war the women of Sidon had acquired celebrity for their skill in embroidery. At a later period, this art was introduced into Greece, probably by the Phrygians (by some considered the inventors); and to such a degree of skill did the Grecian women attain in it, that their performances were said to rival the finest paintings. In our own times the art of embroidery has been cultivated with great success, more especially in Germany and France; and though for a long period it was practised only by the ladies of these countries as an elegant accomplishment, it is now regarded as a staple of traffic, and furnishes employment for a large portion of the population.

EMBROIDERING MACHINE. This art has been till of late merely a handicraft employment, cultivated on account of its elegance by ladies of rank. But a few years ago M. Heilmann of Mulhause invented a machine of a most ingenious kind, which enables a female to embroider any design with 80 or 140 needles as accurately and expeditiously as she could formerly do with one. A brief account of this remarkable invention will therefore be acceptable to many readers. It was displayed at the national exposition of the products of industry in Paris for 1834, and was unquestionably the object which stood highest in public esteem; for whether at rest or in motion, it was always surrounded with a crowd of curious visitors, admiring the figures which it had formed, or inspecting its movements and investigating its mechanism. 130 needles were occupied in copying the same pattern with perfect regularity, all set in motion by one person. Several of these machines are now mounted in France, Germany, and Switzerland. There exists one factory in Manchester, where a great many of them are doing beautiful work.

The price of a machine having 130 needles, and of consequence 260 pincers or fingers and thumbs to lay hold of them, is 5000 francs, or £200 sterling; and it is estimated to do daily the work of 15 expert hand embroiderers, employed upon the ordinary frame. It requires merely the labor of one grown-up person, and two assistant children. The operative must be well taught to use the machine, for he has many things to attend to; with the one hand he traces out, or rather follows the design with the point of the pentograph; with the other he turns a handle to plant and pull all the needles, which are seized by pincers and moved along by carriages, approaching to and receding from the web, rolling all the time along an iron railway; lastly, by means of two pedals, upon which he presses alternately with one foot and the other, he opens the 130 pincers of the first carriage, which ought to give up the needles after planting them in the stuff, and he shuts with the same pressure the 130 pincers of the second carriage, which is to receive the needles, to draw them from the other side, and to bring them back again. The children have nothing else to do than to change the needles when all their threads are used, and to see that no needle misses its pincers.

EMERALD. A mineral of a beautiful green color, which occurs in prismatic crystals, and is much valued for ornamental jewelry. The finest are obtained from Peru. It consists of 65 silica, 16 alumina, 13 glucina, about 3 oxide of chromium (which is the coloring matter), and a trace of lime. The mines from which the ancients obtained emeralds are said to have existed in Egypt, near Mount Zabarah.

EMERY. (From Cape *Emeri*, in the island of Naxos.) A variety of corundum; amorphous, compact, and generally opaque. It is characterized by excessive hardness; and its powder is used for cutting and polishing glass, gems, and all hard substances: it scratches and wears down nearly all minerals except the diamond.

EMETIC TARTAR. A triple salt, composed of oxide of antimony, potassa, and tartaric acid. It is soluble in eighteen parts of cold and in three of boiling water. In the dose of from half a grain to two grains it operates as a powerful emetic and sudorific; in smaller doses, it acts upon the bowels, and is diaphoretic.

EMETINE. A substance discovered in 1817 by Pelletier in ipecacuanha. It is white, pulverulent, and bitter; easily soluble in hot water and alcohol, and intensely emetic. It exists in ipecacuanha to the amount of about 16 per cent., and appears to be the sole cause of its emetic property.

EMPYREUMA means the offensive smell produced by fire applied to organic matters, chiefly vegetable, in close vessels. Thus, empyreumatic vinegar is obtained by distilling wood at a red heat, and empyreumatic oil from many animal substances in the same way.

ENAMELS are varieties of glass, generally opaque and colored, always formed by the combination of different metallic oxides, to which certain fixed fusible salts are added, such as the borates, fluates, and phosphates.

The simplest enamel, and the one which serves as a basis to most of the others, is obtained by calcining first of all a mixture of lead and tin, in proportions varying from 15 to 50 parts of tin for 100 of lead. The middle term appears to be the most suitable for the greater number of enamels; and this alloy has such an affinity for oxygen, that it may be calcined with the greatest ease in a flat cast-iron pot, and at a temperature not above a cherry red, provided the dose of tin is not too great. The oxide is drawn off to the sides of the melted metal according as it is generated, new pieces of the alloy being thrown in from time to time till enough of the powder be obtained. Great care ought to be taken that no metallic particles be left in the oxide, and that the calcining heat be as low as is barely sufficient; for a strong fire frits the powder, and obstructs its subsequent comminution. The powder when cold is ground in a proper mill, levigated with water, and elutriated, as will be described, under *Red lead*. In this state of fineness and purity, it is called calcine, or flux, and it is mixed with silicious sand and some alkaline matter or sea-salt. The most ordinary proportions are, 4 of sand, 1 of sea-salt, and 4 of *calcine*. Chaptal states that he has obtained a very fine product from 100 parts of calcine, made by calcining equal parts of lead and tin, 100 parts of ground flint, and 200 parts of pure subcarbonate of potash. In either case, the mixture is put into a crucible, or laid simply on a stratum of sand, quicklime spontaneously slaked, or wood-ashes, placed under a pottery or porcelain kiln. This mass undergoes a semi-vitrification; or even a complete fusion on its surface. It is this kind of frit which serves as a radical to almost every enamel; and by varying the proportions of the ingredient, more fusible, more opaque, or whiter enamels are obtained. The first of these qualities depends on the quantity of sand or flux, and the other two on that of the tin.

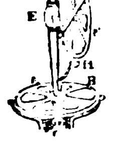
The sea-salt employed as a flux may be replaced either by salt of tartar, by pure potash, or by soda; but each of these fluxes gives peculiar qualities to the enamel.

A patent was granted to Thomas and Charles Clarke, of England, in 1839, for a method of enamelling or coating the internal surfaces of iron pots and saucepans, in such a way as shall prevent the enamel from cracking or splitting off from the effects of fire. The specification prescribes the vessel to be first cleansed by exposing it to the action of dilute sulphuric acid (sensibly sour to the taste) for three or four hours, then boiling the vessel in pure water for a short time, and next applying the composition. This consists of 100 lbs. of calcined ground flints; 50 lbs. of borax calcined, and finely ground with the above. That mixture is to be fused and gradually cooled.

40 lbs. weight of the above product is to be taken with 5 lbs. weight of potter's clay; to be ground together in water until the mixture forms a pasty-consistenced mass, which will leave or form a coat on the inner surface of the vessel about one-sixth of an inch thick. When this coat is set, by placing the vessel in a warm room, the second composition is to be applied. This consists of 125 lbs. of white glass (without lead), 25 lbs. of borax, 20 lbs. of soda (crystals), all pulverized together and vitrified by fusion, then ground, cooled in water, and dried. To 45 lbs. of that mixture, 1 lb. of soda is to be added, the whole mixed together in hot water, and when dry, pounded; then sifted finely and evenly over the internal surface of the vessel previously covered with the first coating or composition, while this is still moist. This is the glazing. The vessel thus prepared is to be put into a stove, and dried at the temperature of 212° Fahr. It is then heated in a kiln or muffle, like that used for glazing china. The kiln being brought to its full heat, the vessel is placed first at its mouth to heat it gradually, and then put into the interior of the infusion of the glaze. In practice it has been found advantageous also to dust the glaze powder over the fused glaze, and apply a second fluxing heat in the oven. The enamel, by this double application, becomes much smoother and sounder.

ENAMEL, FOR PINS, HOOKS AND EYES, &c. The articles to be enamelled, after being thoroughly cleaned and freed from dust and dirt are spread or placed in a basin, dish, or other fit receptacle, where they are wetted with the spirit or oil of turpentine; they are then dried, if required, by artificial means; when dry, the enamel or japan is applied, it taking effect and spreading a coat upon the whole of those parts of the articles previously covered by the turpentine; should it be required to give the articles more coats than one, the same process of applying the enamel is to be repeated, but omitting to apply the spirit of turpentine. The compositions are as follows: for blue, the best varnish or gums, three quarters of a pint; of spirits of turpentine, half a pint; flake white, 1 lb., and prussiate of iron, 1 oz. For red, Persian vandyke, 1 lb.; varnish or gums, half a pint; spirits of turpentine, quarter of a pint. For green, pale chrome, ¼ lb.; varnish or gums, half a pint; spirits of turpentine, quarter of a pint. Other colors or tints may be composed and applied in like manner by varying or altering the proportions of the materials.

ENCAUSTIC PAINTING. In painting, a method of painting used by the ancients, the precise mode of executing which is by no means sufficiently explained. From Pliny's account, it seems that the colors were made up into crayons through a medium of wax, and, the subject being previously traced with a metal point, were melted on the picture as they were used. The picture being finished, a varnish of melted wax was spread over all. The colors thus not only obtained considerable brilliancy, but the work was also protected from the weather. It was lastly well polished. The attempts to revive this art, which, after all, if we may draw our conclusion from Pliny's account, seems to have been but a clumsy process, have not been attended with success.



EQUATORIAL. An astronomical instrument, contrived for the purpose of directing a telescope upon any celestial object of which the right ascension and declination are known, and of keeping the object in view for any length of time, notwithstanding the diurnal motion. For these purposes, a principal axis C D, resting on firm supports, is placed parallel to the axis of the earth's rotation, and consequently pointing to the poles of the heavens. On this polar axis there is fixed, near one of its extremities, a graduated circle A B, the plane of which is perpendicular to the polar axis, and therefore parallel to the earth's equator. This circle is called the *equatorial circle*, and measures by its arcs the hour angles, or differences of right ascension. The polar axis is pierced at E F, and penetrated by the axis of a second circle G H, at right angles to it. The axis of the second circle has consequently no connection with any external support, but is sustained entirely by the polar axis. The plane of the second circle G H, which is called the *declination* circle, and carries the telescope K, is thus in all positions at right angles to the plane of the first or equatorial circle A B. Now it is easy to conceive, from this general description, that when the telescope is pointed to a star, the angle between the direction of the telescope and the polar axis is equal to the polar distance of the star; consequently, when a motion is given to the polar axis without altering the position of the telescope on the declination circle, the point to which the telescope is directed will always lie in the small circle of the heavens coincident with the star's diurnal path; and hence, if the motion communicated to the polar axis be just equal to the earth's diurnal rotation, the star will remain constantly, and as long as we please, in the field of the telescope, at least while above the horizon. In many observations this is indispensable, and it is an advantage which attaches to no other instrument. The polar axis may be moved by a peculiar kind of clock machinery, adjusted to sidereal time; and the best and largest equatorials are now furnished with such an apparatus. Besides relieving the observer from the fatigue of turning the instrument, the motion thus given is perfectly equable, and all those jerks avoided which, when the instrument is turned by the hand, often prove fatal to an observation.

EQUIVALENTS, CHEMICAL. A term introduced into chemistry by Dr. Wollaston to express the system of definite ratios in which substances reciprocally combine, referred to a common standard of unity. If we assume hydrogen as unity, it being the substance which combines with others in the smallest relative weight or proportions, then all other substances may be represented by certain multiples of that unit, expressed with sufficient precision for all ordinary purposes by whole numbers. Thus, upon this system, the equivalent number of oxygen will be 8, and that of water will be 9, for 8 oxygen + 1 hydrogen = 9 water; and the equivalent of potassium will be 40, and of potassa or oxide of potassium 48, for 40 potassium

$+ 8$ oxygen $= 48$ potassa. Upon the same principle the equivalent of hydrochloric acid, which is a compound of chlorine and hydrogen, is 37, for it consists of 1 part by weight of hydrogen and 36 of chlorine; or, in other words, of an atom of hydrogen $= 1 +$ an atom of chlorine $= 36$. The equivalent of sulphur is 16: to form sulphuric acid one atom of sulphur $= 16$ combines with 3 atoms of oxygen $(8 \times 3) = 24$; hence the equivalent of an atom of sulphuric acid is $16 + 24 = 40$. These equivalents are often expressed by certain abbreviations, termed *chemical symbols;* which, as far as single equivalents of the simple substances are concerned, are represented, together with their equivalent numbers, in a table in the article ATOM.

ENGRAVING ON WOOD, or Xylography. In this branch of art the material used is a block of box or pear-tree wood, cut at right angles to the direction of the fibres, the thickness being regulated by the height of the type in the form. The subject is either transferred from a previous print, or else drawn on the block with a black lead pencil, or with Indian ink. The whole of the wood is then cut away except where the lines are drawn, which are left as raised parts. In this it differs from copper-plate engraving, where the lines are cut out, or sunk in the metal. The impressions from wood blocks are taken in the same manner as from printing types.

Copper Engraving is performed by cutting lines representing the subject on a copper plate with a steel instrument, ending in an unequal sided pyramidal point, such instrument being called a graver, or burin, without the use of aquafortis: which mode is described further on. Besides the graver there are other instruments used in the process, viz., a scraper, a burnisher, an oil stone, and a cushion for supporting the plate. In cutting the lines on the copper the graver is pushed forward in the direction required, being held in the hand at a small inclination to the plane of the copper. The use of the burnisher is to soften down lines that are cut too deep, and for burnishing out scratches in the copper: it is about three inches long. The scraper, like the last, is of steel, with three sharp edges to it, and about six inches long, tapering towards the end. Its use is to scrape off the burr, raised by the action of the graver. To show the appearance of the work during its progress, and to polish off the burr, engravers use a roll of woollen or felt called a rubber, which is put in action with a little olive oil. The cushion, which is a leather bag about nine inches diameter filled with sand for laying the plate on, is now rarely used except by writing engravers. For architectural subjects, or in skies, where a series of parallel lines are wanted, an ingenious machine was invented by the late Mr. Wilson Lowry, called a ruling machine, the accuracy of whose operation is exceedingly perfect. This is made to act on an etching ground by a point or knife connected with the apparatus, and bit in with aquafortis in the ordinary way.

Etching is a species of engraving on copper or other metals with a sharp pointed instrument called an etching needle. The plate is covered with a ground or varnish capable of resisting the action of aquafortis. The usual method is to draw the design on paper with a black-lead pencil; the paper being damped and laid upon the plate, prepared as above, with the drawing next the etching ground, is passed through the rolling press, and thus the design is transferred from the paper to the ground. The needle then scratches out the lines of the design; and aquafortis being poured over the plate, which is bordered round with wax, it is allowed to remain on it long enough to corrode or bite in the lines which the etching needle has made. Etching with a dry point, as it is called, is performed entirely with the point without any ground, the burr raised being taken off by the scraper. Etching with a soft ground is used to imitate chalk or black-lead drawings. For this purpose the ground is mixed with a portion of tallow or lard, according to the temperature of the air. A piece of thin paper being attached to the plate at the four corners by some turner's pitch and lying over the ground, the drawing is made on the paper and shadowed with the black-lead pencil. The action of the pencil thus detaches the ground which adheres to the paper, according to the degree to which the finishing is carried; the paper being then removed, the work is bit in the ordinary way. *Stippling* is also executed on the etching ground by dots instead of lines made with the etching needle, which according to the intensity of the shadow to be represented, are made thicker and closer. The work is then bit in. *Etching on Steel* is executed much in the same way as in the process on copper. The plate is bedded on common glazier's putty, and a ground of Brunswick black is laid in the usual way, through which the needle scratches. It is then bit in, in the way above described.

Mezzotinto Engraving. In this species of engraving the artist, with a knife or instrument made for the purpose, roughs over the whole surface of the copper in every direction, so as to make it susceptible of delivering a uniform black, smooth, or flat tint. After this process the outline is traced with an etching needle, and the lightest parts are scraped out, then the middle tints so as to leave a greater portion of the ground, and so on according to the depth required in the several parts of the work.

Aquatinta Engraving, whose effect somewhat resembles that of an Indian-ink drawing. The mode of effecting this is, (the design being already etched) to cover the plate with a ground made of resin and Burgundy pitch or mastic dissolved in rectified spirit of wine, which is poured over the plate lying in an inclined position. The spirit of wine, from its rapid evaporation, leaves the rest of the composition with a granulated texture over the whole of the plate, by which means a grain is produced by the aquafortis on the parts left open by the evaporation of the spirit of wine. The margin of the plate is of course protected in the usual way. After the aquafortis has bitten the lighter parts they are *stopt out*, and the aquafortis is again applied, and so on as often as any parts continue to require more depth. Formerly the grain used to be produced by covering the copper with a powder or some substance which took a granulated form, instead of using the compound above mentioned; but this process was found to be both uncertain and imperfect. In the compound the grain is rendered finer or coarser, in proportion to the quantity of resin introduced. This mode of engraving was invented by a Frenchman of the name of St. Non, about 1662. He communicated it to Jean Baptiste le Prince, who died in 1781, from whom it was acquired by Paul Sandby, who introduced it through the medium of Mr. Jukes into England.

Etching on Glass. The glass is covered with a thin ground of beeswax: and the design being drawn with the etching needle, it is subjected to the action of sulphuric acid sprinkled over with powdered flour of Derbyshire spar. After four or five hours this is removed, and the glass cleaned off with oil of turpentine, leaving the parts covered with the beeswax untouched. This operation may be inverted by drawing the design on the glass with a solution of beeswax and turpentine, and subjecting the ground to the action of the acid.

Engraving on Stone or *Lithography.*—A modern invention, by means whereof impressions may be taken from drawings made on stone. The merit of this discovery belongs to Aloys Senefelder, a musical performer of the theatre at Munich about the year 1800. The following are the principles on which the art of lithography depends: First, the facility with which calcareous stones imbibe water; second, the great disposition they have to adhere to resinous and oily substances; third, the affinity between each other of oily and resinous substances, and the power they possess of repelling water or a body moistened with water. Hence, when drawings are made on a polished surface of calcareous stone with a resinous or oily medium, they are so adhesive that nothing short of mechanical means can effect their separation from it, and whilst the other parts of the stone take up the water poured upon them, the resinous or oily parts repel it. Lastly, when over a stone prepared in this manner a colored oily or resinous substance is passed, it will adhere to the drawings made as above, and not to the watery parts of the stone. It was formerly thought that England did not possess a sort of stone like that of Germany, suitable to the purposes of lithography; this, however, is now known to be erroneous, as the neighborhood of Bath abounds with it, being the white *lias*, which lies immediately under the blue. It is also found in Scotland. The ink and chalk used in lithography are of a saponaceous quality: the former is prepared in Germany from a compound of tallow soap, pure white wax, a small quantity of tallow, and a portion of lamp-black, all boiled together, and when cool dissolved in distilled water. The chalk for the crayons used in drawing on the stone, is a composition consisting of the ingredients above mentioned, but to it is added when boiling, a small quantity of potash. After the drawing on the stone has been executed and is perfectly dry, a very weak solution of vitriolic acid is poured upon the stone, which not only takes up the alkali from the chalk or ink, as the case may be, leaving an insoluble substance behind it, but it lowers in a very small degree that part of the surface of the stone not drawn upon, and prepares it for absorbing water with greater freedom. Weak gum water is then applied to the stone, to close its pores and keep it moist. The stone is now washed with water, and the daubing ink applied with balls as in printing; after which it is passed in the usual way through the press, the process of watering and daubing being applied for every impression.

There is a mode of transferring drawings made with the chemical ink on paper prepared with a solution of size or gum tragacanth, which being *laid on the stone and passed through the press* leaves the drawing on the stone, and the process above described for preparing the stone and taking the impression is carried into effect.

In Germany many engravings are made on stone with the burin, in the same way as on copper; but the very great inferiority of these to copper engravings makes it improbale that this method will ever come into general use.

Perhaps one of the greatest advantages of the art of lithography is the extraordinary number of copies that may be taken from a block. As many as 70,000 copies or prints have been taken from one block, and the last of them nearly as good as the first. Expedition is also gained, inasmuch as a fifth more copies can be taken in the same time than from a copperplate: and as regards economy the advantages over every other species of engraving is very great.

Zincography. This art, which is of very recent introduction in this country (so much so, indeed, that but few specimens are as yet to be seen), is similar in principle to lithography, the surface of the plates of zinc on which it is executed being bit away, leaving the design prominent or in relief. We have seen some beautiful examples of this art, but varying little in their appearance from those of stone engraving.

Mr. J. H. Priny, of England, has proposed a mode of engraving on steel and other metals by means of electricity. He employs six of Smee's batteries, in each the size of the platinized silver plate was about three square inches. The steel plate to be engraved was connected to the zinc end of the batteries; a long covered wire is placed between the steel plate and the zinc. The wire in communication with the platinized silver, was used as an etching point on the steel plate. The wire, which served as a graver, was made of platina; when held a glass tube protected it from the hand. In proportion to the intensity of the current is the depth of the engraving.

ERIOMETER. An optical instrument proposed by the late Dr. Young for measuring the diameters of minute particles and fibres, by ascertaining the diameter of any one of the series of colored rings they produce. "The eriometer is formed of a piece of card or a plate of brass, having an aperture of about a fiftieth of an inch in diameter in the centre of a circle about half an inch in diameter, and perforated with about eight small holes. The fibres or particles to be measured are fixed in a slider; and the eriometer being placed before a strong light, and the eye assisted by a lens applied behind the small hole, the rings of colors will be seen. The slider must then be drawn out or pushed till the limit of the first red and green ring (the one selected by Dr. Young) coincides with the circle of perforations, and the index will then show on the scale the size of the particles or fibres.

ERVA LENTA. The farina or meal of the common lentil, the *Ervum Lens.*

ERMINE. The winter hair of the common weasel an animal indigenous through the whole states. The fur is white, long, thin, and silky. The animals are very abundant about Hudson's Bay. The fur is in great request, and was formerly one of the insignia of magistrates. When used to line cloaks, the black tuft of the tail is sewed to the skin at irregular intervals.

ESSENTIAL OILS or VOLATILE OILS. Under this term are included all those peculiar compounds obtained by distilling vegetable substances with water, and which pass over along with the steam, and are afterwards condensed in the liquid or solid form. They appear to constitute the *odorous* principles of vegetables. Their specific gravity fluctuates on either side that of water; they are very sparingly soluble in water, and these solutions constitute the *medicated waters*; rose, peppermint, and other waters being such solutions of the respective essential oils. They dissolve in alcohol and form *essences*, many of which are used as perfumes. When these oils are pure, they evaporate from paper when held before the fire; but if adulterated with fixed oils, they leave a greasy stain, and seldom dissolve perfectly in alcohol. The more expensive of these oils are frequently adulterated with the cheaper ones, and this fraud can only be detected by an experienced nose. Their chief use is in perfumery, on account of their odour, and in medicine they form valuable stimulants. They are inflammable, and are, with a few exceptions, compounds of hydrogen, oxygen, and carbon. The essence of turpentine, of lemons, and a few others, are *hydrocarbons*.

ETHER. In Chemistry, this term is applied to a highly volatile, fragrant, inflammable, and intoxicating liquid, produced by distilling a mixture of equal weights of sulphuric acid and alcohol. When these liquids mutually act on each other, a series of complicated changes ensue, which terminate in the conversion of alcohol into ether. Ether, like alcohol, may be regarded as a compound of hydrocarbon and water; and if alcohol be considered as consisting of *one* equivalent of olefiant hydrocarbon$=14$, and *one* of water$=9$, either may be regarded as constituted of *two* olefiant hydrocarbon $(14\times2)=28$, and *one* of water$=9$: hence, the equivalent of alcohol being $14+9=23$, that of ether will be $14\times2=28+9=37$; and the process of etherification may be stated to consist in the abstraction from alcohol of one half of its elemental water. By some, ether is regarded as the oxide of a peculiar hydrocarbon, which they term *ethule*, composed of 4 equivalents of carbon and 5 equivalents of hydrogen; and alcohol must in that case be considered as hydrate of ether.

Ether, or, as it is often called, to distinguish it from analogous products obtained by the intervention of other acids, *sulphuric ether*, is a limpid colorless fluid, of an agreeable odour, and a hot pungent taste. Its specific gravity is about 0·718, though that of the shops is usually heavier; it boils at about 98°, and freezes at the low temperature of 46° below 0°. The specific gravity of ethereal vapor compared with atmospheric air is as 258 to 100. Ether is sparingly soluble in water, which takes up about a tenth of its bulk; it dissolves in all proportions in alcohol. The principal use of ether is in medicine. When taken internally, it is stimulant; and it is sometimes applied externally, by reason of the cold produced during its evaporation, as an ingredient in refrigerating lotions.

The most profitable way of manufacturing ether has been pointed out by Boullay. It consists in letting the alcohol drop in a slender stream into the acid, previously heated to the etherifying temperature. If the acid in this case were concentrated to 1·846, the reaction would be too violent, and the ether would be transformed into bicarbureted hydrogen (dihydrate of carbon). It is therefore necessary to dilute the acid down to the density of 1·780; but this dilution may be preferably effected with alcohol, instead of water, by mixing three parts of the strongest acid with two of alcohol, specific gravity 0·830, and distilling off a portion of the ether thereby generated; after which the stream of alcohol is to be introduced into the tubulure of the retort through a small glass tube plunged into the mixture; this tube being the prolongation of a metallic syphon, whose shorter leg dips into a bottle filled with alcohol. The longer leg is furnished with a stop-cock, for regulating at pleasure the alcoholic streamlet. The distilled vapors should be transmitted through a worm of pure tin, surrounded by cold water, and the condensed fluid received in a glass bottle. The quantity of alcohol which can be thus converted into ether by a given weight of sulphuric acid, has not hitherto been accurately determined; but it is at least double. In operating in this way, neither sulphurous acid nor sweet oil of wine is generated, while the residuary liquid in the retort continues limpid and of a merely brownish yellow color. No sulphovinic acid is formed, and according to the experiments of Geiger, the proportion of ether approaches to what theory shows to be the maximum amount. In fact, 57 parts of alcohol of 0·83 sp. grav. being equivalent to 46·8 parts of anhydrous alcohol, yield, according to Geiger, 33¼ parts of ether; and by calculation they should yield 37¼.

The ether of the first distillation is never pure, but always contains a certain quantity of alcohol. The density of that product is usually 0·78, and if prepared by the first of the above methods, contains, besides alcohol, pretty frequently sulphurous acid, and sweet oil of wine; impurities from which it must be freed. Being agitated with its bulk of milk of lime, both the acid and the alcohol are removed at the same time; and if it be then decanted and agitated, first with its bulk of water, next decanted into a retort containing chloride of calcium in coarse powder, and distilled, one third of perfectly pure ether may be drawn over.

ETHER, ACETIC, is used to flavor silent corn spirits in making imitation brandy. It may be prepared by mixing 20 parts of acetate of lead, 10 parts of alcohol, and 11½ of concentrated sulphuric acid; or 16 of the anhydrous acetate, 5 of the acid, and 4½ of absolute alcohol; distilling the mixture in a glass retort into a very cold receiver, agitating along with weak potash ley the liquor which comes over, decanting the supernatant ether, and rectifying it by re-distillation over magnesia and ground charcoal.

Acetic ether is a colourless liquid of a fragrant smell and pungent taste, of spec. grav. 0·866 at 45° F., boiling at 166° F., burning with a yellowish flame, and disengaging fumes of acetic acid. It is soluble in 8 parts of water.

ETCHING VARNISHES. The varnishes of Mr. Lawrence, an English artist resident in Paris, is made as follows: Take of virgin wax and asphaltum, each two ounces, of black pitch and burgundy pitch each half an ounce. Melt the wax and pitch in a new earthenware glazed pot, and add to them, by degrees, the asphaltum, finely powdered. Let the whole boil till such time as that, taking a drop upon a plate, it will break when it is cold, on bending it double two or three times betwixt the fingers. The varnish, being then enough boiled, must be taken off the fire, and after it cools a little, must be poured into warm water that it may work the more easily with the hands, so as to be formed into balls, which must be kneaded, and put into a piece of taffety for use.

Care must be taken, first, that the fire be not too violent, for fear of burning the ingredients, a slight simmering being sufficient; secondly, that whilst the asphaltum is putting in, and even after it is mixed with the ingredients, they should be stirred continually with the spatula; and thirdly, that the water into which this composition is thrown should be nearly of the same degree of warmth with it, in order to prevent a kind of cracking that happens when the water is too cold.

The varnish ought always to be made harder in summer than in winter, and it will become so if it be suffered to boil longer, or if a greater proportion of the asphaltum or brown resin be used. The experiment above mentioned, of the drop suffered to cool, will determine the degree of hardness or softness that may be suitable to the season when it is used.

Preparation of the hard varnish used by Callot, commonly called the Florence Varnish:—Take four ounces of fat oil very clear, and made of good linseed oil, like that used by painters; heat it in a clean pot of glazed earthenware, and afterwards put to it four ounces of mastick well powdered, and stir the mixture briskly till the whole be well melted, then pass the mass through a piece of fine linen into a glass bottle with a long neck, that can be stopped very securely; and keep it for the use that will be explained below.

Method of applying the soft varnish to the plate, and of blackening it:—The plate being well polished and burnished, as also cleansed from all greasiness by chalk or Spanish white, fix a hand-vice on the edge of the plate where no work is intended to be, to serve as a handle for managing it when warm; then put it upon a chafing-dish, in which there is a moderate fire, and cover the whole plate equally with a thin coat of varnish; and whilst the plate is warm, and the varnish upon it in a fluid state, beat every part of the varnish gently with a small ball or dauber made of cotton tied up in taffety, which operation smooths and distributes the varnish equally over the plate.

EUDIOMETER. This term is generally applied to instruments for facilitating the analysis of atmospheric air, or rather for determining the quantity of oxygen contained in a given volume of air; under the idea that the salubrity of the air depended upon its relative quantity of oxygen. We now know, however, that this is not the case, and that the relation of the oxygen to the nitrogen in the atmosphere is not subject to any discernible fluctuation.

EVAPORATION. The conversion of substances into vapour is one of the most important and general effects of heat. During this process, a considerable quantity of sensible heat passes into the *latent* or insensible state. When a vessel of water is placed upon the fire, its temperature gradually rises till it attains 212°; then, although it remains upon the fire, and of course receives heat as before, it does not become hotter, but is gradually converted into steam or vapor; so that the effect of heat is not to elevate temperature, but to change state or form: that is, in the case of water, to convert it into steam. Hence we assume that steam, though not hotter than water, contains a much larger quantity of heat, and this heat again makes its appearance when the steam is condensed or re-converted into water. At whatever temperature vapour is produced, it is similarly constituted; and that which escapes from water at ordinary temperatures, by the process usually called ***spontaneous evaporation***, resembles the former in all respects: hence it is that evaporation is to surrounding bodies a cooling process; and that in the converse change, or the return of the vapor to the liquid state, heat is evolved and rendered sensible. The same general phenomena are observed with all other liquids, and those which evaporate rapidly at common temperatures often give rise to the production of a great degree of cold; such as spirit of wine, or ether. If the latter fluid be suffered to dribble over the bulb of a thermometer, it will cause it to sink below the freezing point of water; and by accelerating similar cases of evaporation, we obtain most intense degrees of artificial cold.

The circumstances that principally influence the process of evaporation are, extent of surface, and the state of the air as to temperature, dryness, stillness, and density.

In evaporating by surfaces heated with ordinary steam, it must be borne in mind that a surface of 10 square feet will evaporate fully one pound of water per minute, or $725 \times 10 = 7250$ gr., the same as over a naked fire; consequently the condensing surface must be equally extensive. Suppose that the vessel is to receive of water 2500 lbs., which corresponds to a boiler 5 feet long, 4 broad, and 2 deep, being 40 cubic feet by measure, and let there be laid over the bottom of this vessel 8 connected tubes each 5 inches in diameter and 5 feet long, possessing therefore a surface of 5 feet square. If charged with steam, they will cause the evaporation of half a pound of water per minute. The boiler to supply the steam for this purpose must expose a surface of 5 square feet to the fire. It has been proved experimentally that 10 square feet surface of thin copper can condense 8 lbs. of steam per minute, with a difference of temperature of 90 degrees Fahr. In the above example, 10 square feet evaporate 1 lb. of water per minute; the temperature of the evaporating fluid being 212° F., consequently $8 : 1 : : 90 : \frac{90}{3}$. During this evaporation the difference of the temperature is therefore $= 30°$. Consequently the heat of the steam placed in connection with the interior of the boiler, to produce the calculated evaporation, should be, $212 + 30 = 242°$, corresponding to an elastic force of 53·6 inches of mercury. Were the temperature of the steam only 224, the same boiler in the same time would produce a diminished quantity of steam, in the proportion of 12 to 30; or to produce the same quantity the boiler or tubular surface should be enlarged in the proportion of 30 to 12. In general, however, steam boilers employed for this mode of evaporation are of such capacity as to give an unfailing supply of steam.

EXPANSION. One of the most common and obvious effects of heat, which expands or enlarges the bulk of all the forms of matter. The expansion of solids by increase of temperature is comparatively small; but it may be rendered sensible by carefully measuring the dimensions of any substance when cold, and again when heated: an iron bar, for example, fitted to a gauge, which shows its length and breadth, will no longer pass through the apertures when heated. Among solids the metals are most expansible and contractile by heat and cold; but they vary much in this respect, as shown in the following table, which exhibits the change of dimensions which several of them undergo when heated, from the freezing to the boiling point of water:—

	Temperature.	
	32°	212°
Platinum	120000	120104
Steel	—	120147
Iron	—	120151
Copper	—	120204
Brass	—	120230
Tin	—	120290
Lead	—	120345
Zinc	—	120360

The average expansion of glass is very nearly the same as that of platinum. The expansibility of different *liquids* is also very variable: ether, for instance, and alcohol, are more expansible than water, and water more than mercury. The expansibility of mercury is applied to a very useful purpose in the construction of the common thermometer. In general all liquids expand and contract in proportion as they are heated and cooled; but to this law there is a remarkable and anomalous exception with regard to ***water***. When a large thermometer tube is filled with water of the temperature of 60°, and placed in a cold situation, or in a freezing mixture of ice and salt, the water goes on shrinking in the tube, till it has attained the temperature of about 40°; and then, instead of continuing to contract till it freezes (as is the case with equal liquids), it slowly *expands*, and actually rises in the tube until it congeals. In this case the expansion above 40° and below 40° seems to be equal; so that the water will be the same bulk at 48° and 32°. This anomalous expansion of water by cold is productive of some important consequences, considered as a natural operation; for if water, like other fluids, went on increasing in density till it froze, the consequence would be that large bodies of water, instead of being only superficially frozen in winter, would be converted throughout into solid masses of ice. Let us take a fresh water lake as an example. The earth being in winter warmer than the air, the heat is withdrawn from the surface of the water by the cold breezes that blow over it; and the whole body of water has its temperature lowered to 40°, *which is the point of its greatest density*, and a temperature perfectly congenial to fish and most other aquatic animals. The cold now continues to operate upon the surface of the water; but, instead of diminishing its bulk, and therefore rendering it *heavier* than the warmer water beneath, it expands it, and renders it *lighter;* so that under these circumstances a stratum of ice-cold water (at 32°) will be found lying upon the mass of warmer water beneath it (at 40°). The influence of the cold continuing, the surface of the lake will soon freeze, but the water immediately below the superficial covering of ice will be found comparatively warm; and as water is almost a non-conductor of heat, it will be a long time before the ice attains any thickness; and the whole body of water, if of any depth, can never freeze throughout. Indeed, it will be obvious that the retardation of freezing will be proportional to the depth of water which has to be cooled, and hence some very deep basins or lakes are scarcely ever even covered by ice.

As liquids are *enlarged* and consequently rendered specifically lighter by heat, very different effects are produced by applying heat to different parts of the vessels containing them. If the heat be applied to the bottom of the vessel, it is soon heated equally throughout, and made to boil; but if the surface only be heated, it may then be boiled and evaporated, while the lower parts remain quite cold.

Aëriform bodies and vapors are the most expansible forms of matter, and they present an important peculiarity; for in other substances each individual has its own degree of expansion and contraction, whereas all pure aëriform bodies expand and contract alike; so that if we accurately determine the expansion and contraction of any one of them, that knowledge applies to all the rest. 100 measures of air, when heated from the freezing to the boiling point of water, suffer an increase of bulk equal to 37·5 parts; so that 100 cubic feet of air at 32° become dilated to 137½ cubic feet at 212°.

EXPLOSION. In natural philosophy, a sudden and violent expansion of the parts of any object. Explosion differs from expansion in this, that whereas the former is always sudden, and only of momentary duration, the latter is the effect of some gradual and continued power, acting uniformly for some considerable time.

EXTRACTS. The older apothecaries used this term to designate the product of the evaporation of any vegetable juice, infusion, or decoction; whether the latter two were made with water, alcohol, or ether; whence arose the distinction of aqueous, alcoholic, and ethereous extracts.

Fourcroy made many researches upon these preparations, and supposed that they had all a common basis, which he called the *extractive* principle. But Chevreul and other chemists have since proved that this pretended principle is a heterogeneous and very variable compound. By the term *extract*, therefore, is now meant merely the whole of the soluble matters obtained from vegetables, reduced by careful evaporation to either a pasty or solid consistence. The watery extracts, which are those most commonly made, are as various as the vegetables which yield them; some containing chiefly sugar or gum in great abundance, and are therefore innocent or inert; while others contain very energetic impregnations. The conduct of the evaporating heat is the capital point in the preparation of extracts. They should be always prepared, if possible, from the juice of the fresh plant, by subjecting its leaves or other succulent part, to the action of a powerful screw or hydraulic press; and the evaporation should be effected by the warmth of a water-bath, heated not beyond 100° or 120° F. Steam heat may perhaps be applied advantageously in some cases, where it is not likely to decompose any of the principles of the plant. But by far the best process for making extracts is in vacuo. It is much easier to fit up a proper apparatus of this kind, than most practical men imagine. The vacuum may either be made through the agency of steam, as there pointed out, or by means of an air-pump. One powerful air-pump may form and maintain a good vacuum under several receivers, placed upon the flat-ground flanges of so many basins, each provided with a stop-cock at its side for exhaustion. The airless basin containing the juice being set on the shelf of a water-bath, and exposed to a proper temperature, will furnish, in a short time, a large quantity of medicinal extract, possessing the properties of the plant unimpaired.

For exceedingly delicate purposes, the concentration may be performed in the cold, by placing saucers filled with the expressed juice over a basin containing sulphuric acid, putting a glass receiver over them, and exhausting its air.

FAINTS. An impure spirit, which comes over at the commencement and termination of distillation. The first is called strong, and the last weak faints. Faints are impregnated with fetid volatile oils, which are unwholesome, and require to be separated by rectification.

FALLING, or weight of bodies; an important phenomenon, which used to be ascribed to gravitation, a translation of the word weights; so that, according to this wordy philosophy, weight was owing to weight. But it is now considered as well proved, that all central force in planets is a necessary result of the *simultaneous* orbit, or progressions, and the rotary motions, and that the direction to the centre is the constant diagonal of those motions, and the increase in the diagonal the exact quantity fallen in a given time. The rotation is a deflection from the line of the orbit motion, and this being much greater, the body deflected by the rotation is carried by the greater motion obliquely to the common centre of both motions. This is obvious in the equatorial plane, but, in latitudes, the diagonal is compounded of the orbit motions as one force, and of the sine and co-sine as to the rotatory or deflective force; and the square of the sine and co-sine being equal to the square of the radius, every where alike, the fall in direction and quantity agrees with that at the equator. The orbit velocity in a second is 98,182 feet, the equatorial circle is 1525 feet nearly, or in the perpendicular 970·85 feet, that 101·1 to 1, and this inversely, as 6.28318 the circle to the radius 1, the resulting force in the radius is 16·08725 feet as the mean fall. *Or*, taking the two motions as 98182 to 1525, and inversely as 4. the square of the diameter to 1, we also get 16·08725. The squaring the forces, and extracting the root of their sum, gives an analagous result, but, for popular explanation, the preceding may suffice.

FALLOW. In agriculture, lands are said to be under fallow when they are without a regular crop of corn or pulse. A naked fallow is one in which the soil remains a whole year without any crop whatever; and a turnip or green crop fallow is one in which the lands after being without a crop from harvest till the beginning of summer, and being properly labored during that period, are sown with turnips or other similar crops in rows, and the grounds cultivated in the intervals. Fallowing was practised by the Romans on all soils whatever, and has been continued through the dark ages, in all the cultivated parts of Europe, so as to have become, till lately, a general habit in the treatment of arable lands. The practice of taking two corn crops, and then allowing the land to rest or lie fallow, was, till the commencement of the present century, prevalent throughout Europe, and it is still a very common practice in most parts of that Continent. It appears to have been first broken through by the Flemings about the end of the 16th century; and subsequently in Britain, with the culture of turnips, above a century and a half later. Fallows, under the most improved systems of agriculture, are no longer had recourse to in the case of free and easily worked soils, where turnip fallows are made, or drill crops of legumes are substituted; but in very strong clays they are still found necessary, and this will probably continue to be the case till by the "frequent drain system," and long-continued culture, the strong clays become friable and fit for the drill husbandry, like the sandy loams and other free soils. A perfect system of agriculture will completely dispense with fallow; under clover and green crops the ground recovers its mineral ingredients, and acquires an addition of vegetable matter; it is thus richer after clover or green cropping than before, or than it would be by naked fallow.

FAN, FANNERS, or FANNING MACHINE. A machine for separating the chaff, husks, dust, or other light matters from seeds which are to be preserved for sowing, or for some other purpose in general or domestic economy. The air is put in motion by a wheel, commonly driven by hand with leaves or fans instead of spokes, directed in a stream against the seeds to be fanned; which seeds are placed in a hopper, so regulated as to proportion their descent through the stream of air to the force of the current created by the fan wheel. Before fanners were invented the process was performed by hand in a manner the reverse of what it is now by machinery; that is, the seeds and refuse to be separated from them were taken up in shovelfulls, and thrown to as great a distance as possible, through the calm air; when the full-bodied seeds, being the heaviest, were found at the greatest distance, and the chaff and other matters nearer, according to their degree of lightness. With the progress of the arts, a system of screens and sieves was added to the fanning machine, in consequence of which, as it separated the seed from every kind of refuse, it is called a winnowing machine; and in that case, it not only separates the chaff and other light matters generally from the heavy matters, but it parts both according to their bulk and weight; so that the seed comes from the winnowing machine fit for being measured up for the market or store-room, and the various kinds of inferior products in a state fit for immediate use.

FARINA. The flour of any variety of corn or starchy root, as the potato, arrow root, &c. It is only a species of pure starch.

FATS occur in a great number of the animal tissues, being abundant under the skin in what is called the cellular membrane, round the kidneys, in the folds of the omentum, at the base of the heart, in the mediastinum, the mesenteric web, as well as upon the surface of the intestines, and among many of the muscles. They vary in consistence, color, and smell, according to the animals from which they are obtained; thus, they are generally fluid in the cetaceous tribes, soft and rank-flavored in the carnivorous, solid and nearly scentless in the ruminants, usually white and copious in well-fed young animals; yellowish and more scanty in the old. Their consistence varies also according to the organ of their production; being firmer under the skin, and in the neighborhood of the kidneys, than among the moveable viscera. Fat forms about one twentieth of the weight of a healthy animal. But as taken out by the butcher it is not pure, for being of a vesicular structure, it is always enclosed in membranes, mixed with blood, blood-vessels, lymphatics, &c. These foreign matters must first be separated in some measure mechanically, after the fat is minced small, and then more completely by melting it along with hot water, passing it through a sieve, and letting the whole cool very slowly. By this means a cake of cleansed fat will be obtained. Many plans of purifying fats have been proposed; one of the best is to mix two per cent of strong sulphuric acid with a quantity of water, in which the tallow is heated for some time with much stirring; to allow the materials to cool, to take off the supernatant fat, and re-melt it with abundance of hot water. More tallow will thus be obtained, and that considerably whiter and harder than is usually procured by the melters.

Fat is deposited in cells in the cellular tissues of the animal; when viewed under the microscope they are partly polygonal, partly reniform particles, which are connected together by very thin membranes. These may be ruptured by mechanical means, then separated by triturating the fresh fats with cold water, and passing the unctuous matter through a sieve. The particles float in the water, but eventually collect in a white granular crystalline appearance, like starch. Each of them consists of a vesicular integument, of the nature of stearine, and an interior fluid like elaine, which afterwards exudes. The granules float in the water, but subside in spirits of wine. When digested in strong alcohol, the liquid part dissolves, but the solid remains. These particles differ in shape and size, as obtained from different animals; those of the calf, ox, sheep, are polygonal, from $\frac{1}{30}$ to $\frac{1}{350}$ of an inch in diameter; those of the sow are kidney-shaped, and from $\frac{1}{50}$ to $\frac{1}{100}$; those of a man are polygonal, and from $\frac{1}{30}$ to $\frac{1}{600}$; those of insects are spherical, and at most $\frac{1}{300}$ of an inch.

Fats all melt at a temperature much under 212° F. When strongly heated with contact of air, they diffuse white pungent fumes, then blacken, and take fire. When subjected to distillation, they afford a changed fluid oil, carbureted hydrogen, and the other products of oily bodies. Exposed for a certain time to the atmosphere, they become rancid, and generate the same fat acids as they do by saponification. In their fresh state they are all composed principally of stearine, margarine, and oleine, with a little coloring and odorous matter.

Fats are true chemical salts, being composed of a fatty acid united to a base. This base is generally *glycerine*. The acids are either *stearic acid*, which is found abundantly in the hard fats, as suet and tallow,

Margaric acid, also a solid, found in the crystalline portion which cold throws out of olive oil; it is also found in animal fats and *oleic acid*, which is found abundantly in olive oil, and all liquid fats and oils.

The properties of stearine and elaine, or of stearic and oleic acids vary at different seasons and under various circumstances; thus, butter, in summer, consists of 60 of oleine and 40 of stearine; in winter, of 37 of oleine, and 63 of stearine; the former substance being yellow, and the latter white. It differs, however, as produced from the milk of different cows, and also according to their pasture.

Animals oils and fats differ only in fluidity, and may be treated of together. Of animal oils, whale oils, and sperm oils are the most generally known in this country: the fats are spermaceti, butter, tallow, lard, and suet. Whale or train oil is extracted from the blubber of the whale, principally the *balena mysticetes*; originally it is a firm solid fat. To obtain the oil, the blubber is melted in large copper vessels, a large quantity of water separates, and on the surface there floats a solid matter called *fenks*, which is probably coagulated albumen; the more moderate the heat, and the shorter its duration, the paler and better the oil. The deep color is owing to too much boiling, and perhaps to blood and impurities mixed with it. The Greenland oil is pale and free from smell, and burns with a pure and bright flame. By adding cold drawn oil it is made more fluid and combustible. Chloride of lime deprives it of its offensive odor. It boils at 600°, and may be distilled, but it then is an altered oil. Sperm oil forms part of the oily substance in the cranium of the spermaceti whale (physeter macrocephalus). The oil is separated by putting the mass in a woollen bag and pressing it, when the oil runs out. This kind of oil is purer than train, and burns away without leaving charcoal on the wicks. The manner of obtaining the solid fats has been given; when soft it is called *lard*, when hard *tallow*. It is insoluble in water and alcohol, melts at 90° or 100°; by raising the heat it becomes acrid, and gives off a pungent vapor. In close vessels it is decomposed, and among other substances yields a large quantity of olefiant gas. It is inflammable, and affords by combustion water and carbonic acid.

FEATHERS, the peculiar covering of birds, consist of the tube, the shaft, and the barbs. The tube is a hollow, transparent, horny cylinder, constituting the root of the feather; the shaft is elastic, and contains a white, dry, and very light pith. The tube contains a vascular substance, composed of numerous cells, joined together, and communicating with each other. This is enveloped by the tube, but communicates with the skin by a small opening at the root of the tube, and is probably the organ by which the feather is nourished. Two sides of the shaft are covered with the barbs, running in a uniform direction; and each barb forms, of itself, a little shaft, which is covered, in a similar manner, with little barbs on each edge. On the wing-feathers, the barbs are broader on one side than on the other; but on the other feathers, they are equal on both sides. The barbs are provided with barbules, by which they are bound so firmly to each other, as to appear to adhere together, although they are, in fact, entirely separate. The feathers of birds are periodically changed. This is called *moulting*.

The best method of curing feathers is to lay them in a room exposed to the sun, and, when dried, to put them in bags, and beat them well with poles. Feathers, when chemically analyzed, seem to possess nearly the same properties as hair.

FEATHERS. (Purification of.)—The following is an outline of Heal's process:—

"The feathers are first placed in what is termed a *steam-cistern*, a chamber of iron, having its floor formed of perforated metal, through which a current of steam is made to enter with considerable force, to fill every portion of the cistern, and thoroughly saturate the mass which it contains. This continues for some time, the effect upon the feathers being analogous to that produced upon metallic substances when exposed to the red heat of a furnace. Every particle of animal matter they contain is fused and driven off, being carried away by the steam as it rushes through the mass and escapes by an aperture for the purpose in the roof of the cistern. The feathers, now of course in a damp state, are next placed in a large hollow cylinder of iron, into which by means of a blowing machine, is carried a rapid current of air, heated by a furnace to a temperature of 300°. This, like the first cylinder, contains a revolving instrument of iron, but having arms or bars of iron; and these, driven at a great velocity, pass through and through the mass, thoroughly separate it, and keep the feathers constantly in motion: thus allowing the current of hot and drying air to permeate them freely, and effectually separating every fibre of them, while through a floor of wire-work passes away a large quantity of dust and refuse, which must be disengaged. Lastly, the feathers are placed in a hollow cylinder of perforated metal, in which revolves a 'fan,' composed of four plates of metal, fixed at equal distances from each other, into a horizontal bar. This is driven with immense velocity, making about 900 revolutions in a minute, and carrying round the feathers with it; the dust, not already removed in the drying cylinder, is separated by the powerful current of air which is driven through them, and, passing the perforations of the cylinder, is carried away by a drain beneath. By this means the feathers are rendered perfectly sweet, pure, and dry."

FELSPAR. An important mineral composed of silica, alumina, and potash, with traces of lime, and often of oxide of iron. Common felspar is of various shades of white and red; it forms an ingredient in granite, and is the base of some other rocks. It is often crystalized, and cleaves into rhomboidal fragments.

FELTING. The process by which different kinds of fur or wool are blended into a compact texture for the manufacture of hats. The anatomical peculiarities of the different hairs or furs are much concerned in the perfection of the felt; they must be such as to enable them to interlace and intertwine with each other. Hare and rabbit fur, wool, and beaver are the chief materials used; they are mixed in proper proportions, and are tossed about by the strokes of a vibrating string or bow till they become duly matted together. The rapid alternations of its motion being peculiarly well adapted to remove all irregular knots and adhesions among the fibres, and to dispose them in a very light and uniform arrangement. This texture, when pressed under cloths and leather, readily unites into a mass of some firmness. This mass is dipped into liquor containing a little sulphuric acid; and, when intended to form a hat, it is first moulded into a large conical figure, and this is afterwards reduced in its dimensions by working it for several hours with the hands. It is then formed into a flat surface, with several concentric folds, which are still further compacted, in order to make the brim, and the circular part of the crown, and forced on a block which serves as a mould for the cylindrical part. The nap, or outer portion of the fur, is raised with a fine wire brush, and the hat is subsequently dyed, and stiffened on the inside with glue.

FENCE. Any continuous line of obstacle interposed by art between one portion of the surface of land and another, for the purpose of separation or exclusion. The kind of obstacle or material differs according to the animals which are to be separated, excluded, or confined, and the nature of the soil and situation. All fences are either live or dead, or a compound of these. Live fences are hedges; that is, rows of shrubs placed close together, and pruned on the sides, so as to form a sort of living wall. Dead fences are either stone walls, mounds of earth, or structures of wood or of other materials raised above the ground's surface, or upon ditches excavated in it. The latter are sometimes filled with water. Mixed fences are those in which some kind of dead fence is used with some kind of live fence; for example, a ditch with a bank of earth on one side, or a ditch with a wall or a hedge on one side; the latter the commonest of all fences. The introduction of fences into agriculture was about as great an improvement in the progress of that art, as that of the principle of the division of labor into the art of manufacture.

FERMENTATION. When certain vegetable substances are dissolved in water, and subjected to a due temperature (between 65° and 85°), they undergo a series of changes which terminate in the production of alcohol or spirit; these changes constitute the phenomena of *vinous fermentation*. Sugar and some ferment are essential to the process; and during the formation of the alcohol the sugar disappears, and carbonic acid is more or less abundantly evolved. The simplest case of fermentation is that of *must*, or of the expressed juice of the grape, which, when exposed, either in close or open vessels, to a temperature of about 70°, soon begins to give off carbonic acid, and to become turbid and frothy; after a time a scum collects upon the surface, and a sediment is deposited; the liquor, which had grown warm, gradually cools and clears, loses its sweet taste, and is converted into *wine*. The chief component parts of must are water, sugar, mucilage, gluten, and tartar. During the fermentation carbonic acid escapes, the sugar disappears, and with it the greater part of the mucilage: the gluten chiefly forms the scum and a portion of the sediment; and the tartar, originally in solution, is thrown down in the form of a colored deposit. It appears, therefore, that the new products, which are *alcohol* and *carbonic acid*, are principally formed at the expense of the sugar; and Gay Lussac's experiments have shown that 45 pounds of sugar are resolved, in the process of fermentation, into 23 of alcohol and 22 of carbonic acid. Sugar and water alone will not ferment; the ingredient requisite to the commencement of the change is the gluten, which absorbs in the first instance a little oxygen from the air, becomes insoluble, and induces the subsequent changes. The reason why grapes never ferment till the juice is expressed, seems to depend upon the exclusion of air by the husk or membranes; and if grapes be bruised in a perfectly close vessel, carefully excluding oxygen, the juice undergoes no change; so that the mere breaking down of the texture of the fruit is insufficient. But a very short exposure of the pulp to air is sufficient to induce that change in the juice which leads on to fermentation, and which is afterwards independent of the further contract of air, the evolution of carbonic acid being exclusively referable to the decomposition of sugar. In *beer* the alcohol is derived from the sugar, original and produced, of the malt. When wine is exposed to air and a due temperature, a second fermentation ensues, which is called *acetous fermentation*, and which terminates in the production of *vinegar*. During this process oxygen is absorbed, and more or less carbonic acid in most cases evolved; but the apparent cause of the formation of vinegar is the abstract of hydrogen from the alcohol, so as to leave the remaining elements in such proportions as to constitute *acetic acid*. Thus alcohol is theoretically constituted of charcoal, water, and hydrogen; and acetic acid of charcoal and water only; the oxygen of the air, therefore, converts the hydrogen of the alcohol into water, and so effects the change into vinegar.

Essential to fermentation are: 1. Sugar, or an equivalent convertible into it. 2. Water. 3. Heat, or increase of atomic activity. 4. Leaven, or yeast. 5. Air.

Without a saccharine substance the fermentation is acetic, or vinegar; with it the fermentation is vinous, or spirituous. These are followed by decomposition or putrescence, called the ultimate, or putrefactive fermentation.

It is most rapid from 70° to 100°. No vinous or beer fermentation takes place below 55°; and above 100° the acetous precedes the vinous while the alcohol evaporates as formed. It is slower as the heat, or atomic activity, descends towards 55°, and quicker as it advances towards 100°. Again, heat should rise inversely as quantity; 100 gallons will do best at 94°; 450 gallons at 72°, and 2000 gallons at 63°. Small vessels part with heat more rapidly than great ones; and the time is inversely as the heat; 100 gallons at 63° would take 8 days instead of 2. Again, fermentation generates from 2° to 22° of heat, as quantity and strength, and the sinking of this internal heat to that of the surrounding atmosphere, is the signal for the termination of the fermentation. No operation should be attempted where the atmosphere is less than 50°, and, when less, doors and vents should be closed, and fires lighted. If the atmosphere is 80° or 90°, the liquid must be set to work at 70° or 80° and smaller vessels used in summer than in winter. By regulating the heats, fermentation may be conducted with success in every season.

When fermentation is arrested, bottles or casks of hot water must be immersed, or water added to raise the temperature,

When the fermentation is too rapid, it can be checked either by adding a strong solution of wort or syrup, or cooling with jets and ventilation, or by evaporation from the outside of the fermenting vessel.

Whatever diminishes the strength of the wort, or must, increases the fermentation; whatever increases the strength diminishes the fermentation.

Heat also increases it, and cold diminishes it.

No fermentation takes places in a vacuum, or in carbonic acid gas, and air is essential; but, it is not necessary to leave the fermenting liquor uncovered, since the air penetrates and has saturated all the materials. When the fermentation has commenced, air favors the acetous more than the vinous fermentation. Much mixture with air converts the ferment to vinegar; and while the fermentation lasts, the liquor is protected by a stratum of carbonic acid gas lying over it.

FERN ROOT. The root of the *Aspidium filix mas*, or male fern. About two drachms of the dried root, in powder, followed up by a brisk purge, is occasionally given as a vermifuge. It was Madame Nouffer's celebrated specific.

FERROCYANIC ACID. A compound of 3 atoms of cyanogen, 2 of hydrogen, and 1 of iron. It is the *ferrochyazic acid* of Mr. Porrett, the term *chyazic* being composed of the initials of carbon, hydrogen, and azote, which are the ultimate elements of hydro-cyanogen.

FIBRE. One of the two bases of all vegetable structures. It may be compared to hair in inconceivable fineness, its diameter often not exceeding 1-1200 of an inch; also the name of the finer divisions of roots.

FIBRIN. A term applied by chemists to the muscular fibre when cleansed by washing from all adhering impurities; or to the coagulum of the blood when the whole of the coloring matter is washed out of it. It is white, insipid, and inodorous; its ultimate elements are, according to Gay Lussac and Thenard—

Carbon	53·36
Hydrogen . . .	7·02
Nitrogen . . .	19·93
Oxygen	19·69

It is merely a form of *albumen*.

FIBROLITE. A rare mineral of a peculiar fibrous texture, accompanying *corundum* from the Carnatic and from China.

FILE. This instrument is formed by cutting teeth upon a plate or tool of soft steel by the repeated blows of a straight-edged chisel. These teeth either form a single series of straight lines, or they are crossed by a second series; the former are called *single cut*, the latter *double cut* files. Files are required to be extremely hard; and unless they are carefully and skilfully hardened, they are apt to warp. The best files are made exclusively of cast steel, and are cut by hand, none of the file-cutting machines producing unexceptionable tools.

FILLIGREE WORK. This work is a kind of enrichment on gold or silver, wrought delicately in the manner of little threads or grains, or both intermixed. In this kind of work, fine gold and silver wire are often curled in a serpentine form and braided through each other, or formed into festoons and various ornaments, entwisting the threads to give them a very beautiful effect. This art is very ancient, and was brought into Europe from the east. It was formerly much used for decorating images and the tombs of saints. The Hindoos and Chinese make some beautiful works of this kind, with tools which are very coarse and clumsy. The Malay jewellers make a great deal of silver filligree work, and gold also. They either melt their gold in an earthen rice pot or in a clay crucible. They blow their fires with their mouth, through bamboo tubes, and they draw their wire much as we do ourselves; after having drawn it sufficiently fine, they flatten it on the anvil, and give it a peculiar twist by rubbing it on a block with a flat stick. They then form it into leaves and flowers by handiwork, until they have the number to form the pattern they wish to execute on the plate. They always have the pattern beside them of the full size they wish to form on the gold plate. They fix their work with a glutinous substance made of a berry ground on a stone. They keep this substance on a piece of cocoa nut. After all the leaves of the filligree is laid on the plate—stuck on bit by bit—a solder is prepared of gold filings and borax moistened with water, which they strew over the plate, then put it in the fire till the whole becomes united. In making open work the foliage is stuck on a card with the berry paste, then the work is strewn over with the solder and put into the fire, when the card burns away and the whole remains united. If the piece is very large it is soldered several times. When the filligree is finished, they cleanse it by boiling it in common salt water and alum, and they give it a fine purple color by boiling it in water with sulphur. Except in India, China, and some parts of Turkey, this art is much neglected at present.

FILTRATION is a process purely mechanical, for separating a liquid from the undissolved particles floating in it, which liquid may be either the useful part, as in vegetable infusions, or of no use, as the washings of mineral precipitates. The filtering substance may consist of any porous matter in a solid, foliated, or pulverulent form; as porous earthenware, unsized paper, cloth of many kinds, or sand. The white blotting paper sold by the stationers, answers extremely well for filters in chemical experiments, provided it be previously washed with dilute muriatic acid, to remove some lime and iron that are generally present in it. Filter papers are first cut square, and then folded twice diagonally into the shape of a cornet, having the angular parts rounded off. Or the piece of paper being cut into a circle, may be folded fan-like from the centre, with the folds placed exteriorly, and turned out sharp by the pressure of the finger and the thumb, to keep intervals between the paper and the funnel into which it is fitted, to favor the percolation. The diameter of the funnel should be about three fourths of its height, measured from the neck to the edge. If it be more divergent, the slope will be too small for the ready efflux of the fluid. A filter covered with the sediment is most conveniently washed by spouting water upon it with a little syringe. A small camel's-hair paint brush is much employed for collecting and turning over the contents in their soft state. Agitation or vibration is of singular efficacy in quickening percolation, as it displaces the particles of the moistened powders, and opens up the pores which had become closed. Instead of a funnel, a cylinder vessel may be employed, having its perforated bottom covered with a disc of filtering powder folded up at the edges, and made tight there by a wire ring. Linen or calico is used for weak alkaline liquors; and flannels, twilled woollen cloth, or felt-stuff, for weak acid ones. These filter bags are often made conical like a fool's cap, and have their mouths supported by a woollen or metallic hoop. Cotton wool put loose into the neck of a funnel answers well for filtering oils upon the small scale. In the large way, oil is filtered in conical woollen bags, or in a cask with many conical tubes in its bottom, filled with tow or cotton wool. Stronger acid and alkaline liquors must be filtered through a layer of pounded glass, quartz, clean sand, or bruised charcoal. The alcarrhazas are a porous biscuit of stoneware made in Spain, which are convenient for filtering water, as also the porous filtering-stone of Teneriffe, largely imported into England at one time, but now superseded in a great measure by the artificial filters patented under many forms, consisting essentially of strata of gravel, sand, and charcoal powder.

FIREARMS. (*See* GUN, 230.) A new gun has been invented by Mr. M. Cass, of Utica, N. Y. This gun is loaded at the breech with ball cartridge, having chambers for twenty-six charges. It is also capped at the same time that it is charged. These twenty-six charges can be fired in about three minutes without using any particular haste. The cartridge is introduced in the barrel of the gun through the breech-pin, which is constructed something in the manner of a common faucet, being turned one quarter round by a small lever underneath the barrel, and thus admitting the charge, which is thrust forward from its chamber by a small ramrod operating from behind by means of another small lever.

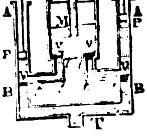
A new breech-loading musket has been invented in Prussia, which may be shortly described thus:—

"The musket has no lock, and is loaded at the stock end of the barrel. The barrel is slightly rifled, but the grooves are perfectly straight, and not spiral, as in the American gun. The common charge is one-half of that used in the old percussion gun, and is said to carry the ball to its mark nine hundred yards. None of the powder is wasted, the fire being communicated from the side of the barrel, and not from the breech. This is effected by an ingenious contrivance. The part of the cartridge next the ball is filled with an explosive substance similar to that in a percussion cap. This is made to explode by the contact of a piece of steel about the length of an eight-penny nail, which passes from the outside of the barrel through the cartridge. The gun is called the "nail firer." It can be discharged by a common soldier eight times in a minute, and need not be taken from the shoulder to be reloaded.

FIRE BLAST. A term of very doubtful meaning, like the word blight. In agriculture it is sometimes applied to plants which are suffering from the mildew fungi, or from minute insects; but its legitimate use would appear to be applicable only when the delicate parts of plants are too suddenly exposed to a brilliant sun, and the rapid transpiration which takes place in consequence dries up and shrivels their leaves.

FIREDAMP. The carburetted hydrogen gas of coal mines.

FIRE ENGINE. This most useful machine is constructed in a variety of forms, which all, however, agree in one principle. It generally consists of a double forcing pump communicating with the same air vessel; and instead of a force-pipe a flexible leathern hose is used, through which the water is driven by the pressure of the condensed air in the air vessel. The annexed diagram represents a section of the apparatus. The pipe T descends into a receiver or vessel containing a supply of water. This pipe communicates with two suction valves V, which open into the pump barrels of two



forcing pumps A, B, in which solid pistons P, are placed. The piston rods of these are connected with a working beam F, elongated so that a number of persons may work at both ends of it at once. Force-pump barrel above the valves V, and pipes *t*, *t*, proceed from the sides of the they communicate with an air vessel M, by means of forcing valves V, which also open upwards. The pipe descends into the air vessel near the bottom. This pipe is connected with the flexible leathern hose L, the length of which is adapted to the purposes to which the machine is to be applied. The extremity of the hose may be carried in any direction, and may be introduced through the doors and windows of buildings. By the alternate action of the pistons, water is drawn through the suction valve, and propelled through the forcing valves, until the air in the top of the vessel M is highly compressed. The pressure acts on the surface of the water in the vessel, and forces it through the leathern hose in a continued stream, so as to spout from its extremity with a force depending partly on the degree of condensation, and partly on the elevation of the extremity of the hose above the level of the engine. It is to be considered that the pressure of the condensed air has, in the first instance, to support a column of water, the height of which is equal to the level of the end of the tube above the level of the water in the air vessel; and until the pressure exceeds what is necessary for this purpose, no water can spout from the end of the hose; and, consequently, the force with which it will so spout will be proportional to the excess of the pressure of the condensed air above the weight of the column of water, whose height is equal to the elevation of the end of the hose above the level of the water in the air vessel.

A steam fire-engine has been built by Mr. Braithwaite, of London, for the King of Prussia. It is intended to be exclusively employed for the protection of the public buildings of Berlin.

The combustion is promoted by means of an exhauster, instead of a bellows; the flue is in two lengths, and the greatest diameter 5 inches. The steam-cylinder is 12 inches in diameter, with a 14 inch stroke. The water cylinders are 10¼ inch. in diameter, with also a 14 inch stroke. The steam from the eduction-pipe is conveyed through two coils of tubing laid in the water tank, and imparts a considerable degree of heat to the water before it is transferred to the boiler. The feed pump is equal to the supply of from 20 to 25 cubic feet of water per hour.

The steam is got up (in 20 minutes.) and the pressure in the boiler is at 70 lbs. the square inch. The height to which the water is ejected is not less than from 115 to 120 feet. The number of strokes per minute is 18, which gives for the quantity of water thrown 1 ton 7 cwt. 18 lbs. per minute.

The water cylinder being 10¼ in diameter, the area of the water piston must be 86·6 square inches;

And a 14-inch stroke of the engine gives for the length of the stroke in the water cylinder 56 inches;

Therefore, 86·6 × 56 = 4849·6 cubic inches of water each stroke = 2·8 cub. ft. Deduct for back-water through the valves 1 cub. ft., leaves for the effectual result 2·7 cub. ft.

And, multiplying 2·7 by 18, the number of strokes per minute, we have 48·6 cubic feet per minute = 3037 lb.s = 1 ton 7 cwt. 18 lbs.

Two pipes were afterwards substituted, of 7-8 inch in diameter; then four of 5-8 inch in diameter; and the effects produced in each instance was as nearly as possible equivalent to that obtained by the 1¼ inch jet.

The average working power of the engine is between 80 and 90 tons of water per hour.

The consumption of coke is about three bushels.

For the supply of the great quantity of water necessary for the engine, cast-iron suction-pipes are to be laid under the pavement, with plugs to which the suction of the engine may be fixed. In consequence of this arrangement, the engine may be used as well for extinguishing fire itself as for supplying other engines with water. As there are 400 ft. of hose belonging to it, the water may even by that means be conveyed to great distances; and a large plane may be protected by placing the engine into a circle, the radius of which is 400 feet. This powerful engine requires an engineer, a stoker, and 1 to 4 men to attend to the hose. It saves the strength of 42 to 105 men, according to its size from 6 to 15 horse power. It does not tire, works regularly, and requires no relief.

Cooper's Rotatory Fire Engine is on the *rotative principle*, worked by 18 men, with 11 inch lever. It discharges through a 4 inch pipe, more water than three 8 inch cylinders, with 9 inch strokes, and 15 inch lever, worked by 34 men—and as much water as four 6¼ inch cylinders, 9 inch strokes, worked by 36 men with 24 inch lever. This experiment was made at New-York, in September, 1827. The same engine with 12 men, 11 inch lever, threw more water than 2 engines, worked by 36 men, with 24 inch lever.

A rotative engine, with 20 men, exerting an estimated power of 35 lbs. per man, with 7 inch lever, has thrown from an inch pipe, 156 ft. horizontal, and 109 ft. in height.

A rotative engine, with 8 men, exerting an estimated power of 50 lbs. per man, has thrown from a half-inch pipe, 148 ft. horizontal, and 108 ft. in height.

The quantity of water discharged by the first engine was 525 gallons for each 100 revolutions. By the second, 304 gallons, each 100 revolutions. By the third, 128 gallons, each 100 revolutions.

In the first engine the revolving cylinder was 18 inches long and 8 inches in diameter, and the surface acting upon the water was 40 square inches. In the second the revolving cylinder was 12 inches long and 6¼ inches in diameter, and it had a surface of 30 square inches. The third cylinder was 9 inches long, 5 inches in diameter, and 18 square inches acting surface.

It raised double the quantity of water, since in working the old engines, to discharge the chamber or cylinder once, the piston must pass twice through it; an ascending stroke to create a vacuum, and a descending one to force the water. Half the time is consequently lost. In the rotative, a continued vacuum is created, and a continued discharged effected.

It works with one-half the power, since the air-vessel is totally dispensed with; and the power is applied directly upon the water. It operates on no more than it discharges. On the other hand, as a consequence of the alternating motion of the piston engines twice the surface is acted on, and the friction of course is comparatively twofold.

FIRE ESCAPE. Any machine or apparatus for the purpose of enabling persons to escape from the upper stories of houses on fire. The contrivances which have been proposed for accomplishing this desirable object are very numerous, and are of two kinds; the first kind comprising those by means of which the escape is effected without external aid, and the second those requiring the assistance of persons without. Of the first kind the most obvious is a rope-ladder, which may be kept in a sleeping apartment, and used upon occasion by fastening one end of it to a window-sill or bed-post. Mr. Maseres contrived an apparatus which consists of a long rope and an assemblage of cordage or belts, so disposed as to form a seat; the person about to descend binds himself into the seat, and then lowers himself to the ground by allowing the rope which is fastened to the window-sill to slide slowly through his hands; and in order that this may be done easily, the rope is made to pass through a series of holes in a block. But unfortunately contrivances of this kind can rarely be expected to be of any use; for supposing them at hand when the alarm of danger is given, few persons can command the coolness and attention which are requisite for fixing and adjusting the apparatus; and even then it is only the strong and active who could safely descend by such means from a considerable height.

With regard to escapes of the second kind, the object is to enable persons without to establish speedily a communication with an upper room, so as to afford the inmates the means of safe descent; or to remove them if necessary, as in the case of the feeble or children. A very portable sort of ladder, invented by Mr. Young, is described in the *Transactions of the Society of Arts* for 1813. It consists of a number of cross bars or rounds, connected with ropes, which form the sides of the ladder; the end of the rounds are fitted into each other, so as to form a pole, which is readily elevated to a window; and at the extremity is an iron frame terminating in hooks which can be lodged in the window-sill. When the hooks are properly fixed, a sudden jerk suffices to separate the rounds, which immediately fall into their places when the ladder is formed and suspended from the frame. But this apparatus only answers the same purpose as a rope-ladder, and is therefore liable to the same objections. Mr. Brady's fire escape, described in the 34th vol. of the same Transactions, consists of a car or cradle, which is made to slide on a slip of plank fixed to a pole, and is governed by a rope. Mr. Ford's escape consists of a spar of timber about 35 or 40 feet long, having two projecting arms at the top furnished with prongs, by which a firm bearing against the wall of a house is obtained. A grooved pulley is mortised into the spar near the top, and another near the bottom; over the pulleys runs an endless rope, to which is attached at one point a main rope, and at another the semicircular brace of a large grooved roller, which traverses up and down the space between the pulleys. This brace carries on the under side of the spar a hook, to which a cradle is attached, whereby persons can be easily lowered to the ground.

FIRE, GREEK. This fire, which was employed in the wars of the Christians and Saracens in the middle ages, is said to have been invented during the reign of Constantine Pogonatus in the year 668 by Callinicus, an architect of Heliopolis. Naphtha was probably is principal ingredient, which, if skilfully projected and inflamed, creates great havoc and dismay, in consequence of its extreme combustibility and the difficulty of quenching its flame.

FIRE-LOCK, or FUSIL. A musket or small gun, which is fired with a flint and steel; and thereby distinguished from the old musket, or *match-lock*, which was fired with a match. The date of the invention of fire-locks is uncertain.

FIRE-WORKS. Artificial preparations made of gunpowder, sulphur, and other inflammable ingredients, displayed at public rejoicings and on other occasions. (*See* Pyrotechny.)

FISH-HOOKS, are constructed with simple tools, but require great manual dexterity in the workmen. The iron wire of which they are made should be of the best quality, smooth, and sound. A bundle of such wire is cut in lengths, either by shears or by laying it down upon an angular wedge of hard steel fixed horizontally in a block or anvil, and striking off the proper lengths by the blows of a hammer. In fashioning the *barbs* of the hooks the straight piece of wire is laid down in the groove of an iron block made on purpose, and is dexterously struck by the chisel in a slanting direction, across so much of the wire as may be deemed necessary. A sharp-pointed little wedge is thus formed, whose base graduates into the substance of the metal.

The end of the wire where the line is to be attached is now flattened or screw-tapped; the other end is sharp-pointed, and the proper twisted curvature is given. The soft iron hooks are next case-hardened, to give them the steely stiffness and elasticity, by imbedding them in animal charcoal contained in an earthen or iron box; (*see* Case-Hardening;) after which they are brightened by heating and agitating them with bran, and finally tempered by exposure to a regulated temperature upon a hot iron plate. Hooks for salt-water fishing are frequently tinned, to prevent them wearing rapidly away in rust. (*See* Tin Plate.)

FIXED OILS. There are two specimens of oil in vegetables, agreeing in the common properties of unctuosity and inflammability, but essentially different in many of their chemical qualities. The one capable of being volatilized without decomposition, is named *volatile oil*, the other is *fixed oil*.

The latter is generally contained in the seeds and fruits of vegetables, and varies in its properties, according to the plants from which it is obtained by pressure, and frequently called *expressed oils*. When the process is aided by heat, the action of which is to render the oil more fluid, the product is esteemed less pure. The purest fixed oils are those expressed from the fruit of the olive, or the seeds of the almond; others, less pure, come from the flax-seed and hemp-seed. These oils are usually fluid, but of a somewhat thick consistence, and liable to congeal at very moderate colds; palm-oil is even, naturally, concrete. When fluid, they are transparent, of a yellow or yellowish-green color, and capable of being rendered quite transparent by the use of animal charcoal. They are inodorous and insipid, at least if they have been obtained with due care; and free from the mucilaginous and extractive matter of the plants from whence they come; are lighter than water, with which they do not unite, and are very sparingly soluble in alcohol, with the exception of castor-oil. At a temperature below 600° Fahr., they remain unchanged.

Near this temperature, however, they begin to boil, and to disengage an inflammable vapor; but the oil thus condensed is altered in its properties; it loses its mildness, becomes more limpid and volatile, a portion of carbon being likewise deposited. Transmitted through an ignited tube, fixed oil is converted into carbonic acid and carbureted hydrogen, with a small portion of acid liquor, and a residuum of charcoal. In the open air, it burns with a clear white light, and formation of water and carbonic acid gas. Accordingly, the fixed oils are capable of being employed for the purposes of artificial illumination, as well in lamps as for the manufacture of gas. Fixed oils undergo considerable change by exposure to the air. The rancidity which then takes place is occasioned by the mucilaginous matters which they contain becoming acid.

From the operation of the same cause, they gradually lose their limpidity, and some of them, which are hence called *drying-oils*, become so dry, that they no longer feel unctuous to the touch, nor give a stain to paper. This property, for which linseed-oil is remarkable, may be communicated quickly, by heating the oil in an open vessel. The drying-oils are employed for making oil-paint, and, mixed with lamp-black, constitute printers' ink.

During the process of drying, oxygen is absorbed in considerable quantity. This absorption of oxygen is, under certain circumstances, so abundant and rapid, and accompanied with such a free disengagement of caloric, that light, porous, combustible materials, such as lamp-black, hemp, or cotton-seed may be kindled by it. Many instances of spontaneous combustion have occurred from this cause. It appears that if hemp, flax, or linen cloth, steeped in linseed-oil, lie in a heap, and be somewhat pressed together and confined, its temperature rises, a smoke issues from it, and, at length, sometimes within 24 or even 12 hours, it takes fire. The same thing happens with mixtures of oil and fine charcoal, and with lamp-black wrapped up in linen; from whence it is conjectured, that many extensive fires, which have broken out in cotton manufactories, and for which no cause could be assigned, must have arisen from this spontaneous inflammability of oils.

Fixed oils unite with the common metallic oxides. Of these compounds, the most interesting is that with the oxide of lead. When linseed-oil is heated with a small quantity of litharge, a liquid results which is powerfully drying, and is employed as oil-varnish. Olive-oil, combined with half its weight of litharge, forms the common *diachylon plaster*. The fixed oils are readily attacked by alkalies. With ammonia, they form a soapy liquid, to which the name of *volatile liniment* is applied.

They are oxidated by a number of the acids. Sulphuric acid soon renders them black; the oxygen of the acid attracting part of the hydrogen of the oil, and causing the deposition of charcoal; and, if heat is applied, a large portion of sulphurous acid is disengaged, and even sulphur is evolved. Nitric acids renders them thick; if heat is applied, the action is more rapid, and a yellow color is communicated, the oil being rendered concrete. Chlorine thickens oil, and renders it white. When boiled in sulphur, a compound is formed of a brown color, a very fetid smell, and acrid taste. It likewise, when heated, dissolves phosphorus, forming a liquid which becomes luminous, when exposed to the air. Olive-oil consists of carbon 77·213, oxygen 9·427, and hydrogen 13·360.

FLAKE WHITE, is the name sometimes given to pure white-lead.

FLAME, is the combustion of an explosive mixture of an inflammable gas or vapor with air. That it is not, as many suppose, combustion merely at the exterior surface, is proved by plunging a fragment of burning phosphorus or sulphur into the centre of a large flame of alcohol. Either of these bodies will continue to burn there with its peculiar light; thus proving that oxygen is mixed with the whole of the burning vapor. If we mix good coal gas with as much atmospheric air as can convert all its carbon into carbonic acid, the mixture will explode with a feeble blue light; but if we mix the same gas with a small quantity of air, it will burn with a rich white flame. In the latter case the carbonaceous particles are precipitated, as Sir H. Davy first showed, in the interior of the flame, become incandescent, and constitute white light: for from the ignition of solid matter alone can the prismatic rays be emitted in that concentrated union. Towards the interior of the flame of a candle, a lamp, or a gas jet, where the air is scanty, there is a deposition of solid charcoal, which first by its ignition, and afterwards by its combustion, increases in a high degree the intensity of the light. If we hold a piece of fine wire gauze over a jet of coal gas close to the orifice, and if we then kindle the gas, it will burn above the wire with its natural brilliancy; but if we elevate the gauze progressively higher, so as to mix more and more air with it before it reaches the burning point, its flame will become fainter and less white. At a certain distance it becomes blue, like that of the above explosive mixture. Since the combustion of all the constituents is in this case direct and complete, the heat becomes greatest in proportion nearly as the light is diminished. If a few platina wires be held in that dim flame they will grow instantly white hot, and illuminate the apartment. On reversing the order of this experiment, by lowering progressively a flat piece of wire gauze from the summit towards the base of a gas flame, we shall find no charcoal deposited at its top, because plenty of air has been introduced there to convert all the carbon of the gas into carbonic acid, and therefore the apex is blue; but as we descend, more and more charcoal will appear upon the meshes. At the very bottom, indeed, where the atmospheric air impinges upon the gauze, the flame is again blue, and no charcoal can therefore be deposited.

The fact of the increase of the brilliancy and whiteness of flame by the development and ignition of solid matter in its bosom illustrates many curious phenomena. We can thus explain why olefiant gas affords the most vivid illumination of all the gases; because, being surcharged with charcoal, its hydrogen lets it go in the middle of the flame, as it does in an ignited porcelain tube, whereby its solid particles first get ignited to whiteness, and then burn away. When phosphorus is inflamed it always yields a pure white light, from the ignition of the solid particles of the snowy acid thus produced.

In the blowpipe the inner blue flame has the greatest heat, because there the combustion of the whole fatty vapor is complete. The feeble light of burning hydrogen, carbonic oxide, and sulphur, may, upon the principles now expounded, be increased by simply placing in them a few particles of oxide of zinc, slender filaments of amianthus, or fine platina wire. By narrowing the top of a long glass chimney over an argand flame either from oil or coal gas, the light can be doubled at the same cost of material. The very tall chimneys used by the Parisian lampists are very wasteful. The light of a flame may be increased by diminishing its heat, or the intensity of its combustion; and conversely the heat of flame may be increased by diminishing its light.

FLATTING. In architecture, a coat of paint, which, from its mixture with turpentine, leaves the work flat, or without gloss.

FLAX. An annual plant, the *linum usitatissimum*, grown extensively, from remote antiquity, over Europe, Asia, and Northern Africa. It is believed to be indigenous to Persia. It rises between two and three feet high, and is chiefly grown either for the seeds, which lie in capsules of ten cells, each cell containing one seed, or for the fibre yielded by the bark, of which linen cloth is made. The use of linen is so ancient that there is no tradition of its introduction. The Scandinavian and other northern tribes knew its use, and the mummies of Egypt are covered with it. Immense quantities are still made at the mouth of the Nile, where it forms almost the sole clothing. It supplies most of Africa and Italy to a great extent. From Egypt its use passed into Greece, and thence into Italy. Besides being used as apparel, the rags when worn out and made into a paste, are converted into paper. The seeds of the flax are mucilaginous and emollient, and an infusion constitutes a medicinal drink. They also yield an oil, well known in commerce as *linseed oil*, which differs from most expressed oils, as in congealing in water, and not forming a solid soap with fixed alkaline salts. The oil has no remarkable taste, and is used in lamps, and occasionally in cookery, and also forms the base of all the oily varnish made in imitation of China varnish. It is much used in coarse painting, as where there is not much exposure to weather. Lime water and linseed oil constitutes one of the best applications to recent burns. The cakes which remain after the oil is expressed are used for fatting cattle and sheep, for which they are very serviceable: they are occasionally used as manure. Flax-seed has been used instead of cereal grains in years of scarcity, but it is a heavy and unwholesome food.

By attention and careful cultivation good flax may be grown on various soils: the soil best suited is a sound, dry, deep loam, with a clay subsoil. Draining is almost necessary for flax lands, for on too damp grounds good flax will not grow. In Flanders flax is grown in the fifth year of a seven course shift, or the fifth year of a ten course shift. It is hardly advisable to cultivate it more frequently than once in seven years. It is usually grown after a grain crop, as oats coming after old lea, or a green crop; or it grows well after potatoes coming after lea. The ground should be ploughed two or three times, once in autumn and twice in spring; it should be harrowed twice early in spring, to bring the land into good tilth, and clean it thoroughly from weeds and roots. The Riga and Dutch seeds produce the finest flax. The seed of this country, though it gives an abundant crop, yet produces a coarse branchy stem, and should only be used on deep loamy soils. Two bushels, or a little over per acre, is the fair quantity for sowing. It is better to sow thickly, for the stems grow taller and straighter, with only two seed capsules at top, and the fibre is superior in fineness and length. Grass-seed and clover should not be sown with it, but carrots may be drilled in between the rows, if flax be so sown. The ground should be wed frequently, and pulled carefully. The best time for pulling is before the seed is quite ripe; if pulled two soon there is waste in the after preparation; if too late, the fibre is coarse. When the seeds begin to change from green to pale brown, then the flax should be pulled. The separation of the seed from the stem is called *rippling*. It should be done on the field, and the ripple is a comb or row of iron teeth screwed into a block of wood; this is screwed on a plank resting on stools. A sheet is spread underneath, and by drawing the flax across the comb, the seeds are separated, and fall upon the sheet; these are afterwards riddled and fanned, to separate chaff, &c., and then dried. Heretofore flax has been prepared by cold steeping in river water, the flax being fully immersed. Here the soft parts of the plant ferment, and the fibre separates away. The time of steeping varies from eight to fourteen days. The plant is then removed, and spread on grass to dry. It is now fit for breaking and skutching. The treatment of flax and hemp should be carried on alike, the fibre of both being capable of being obtained in same way. There can be no doubt that chemical processes, and steam with warm water, will completely supersede the cold water and grass processes. Breaking is sometimes performed by beating the flax with the hand and hammer, which bruises the wood and separates the fibres; a rude machine, called a hand-brake, is sometimes used for this purpose. The machines do this work more effectually. They consist of many deeply fluted rollers of wood or iron, whose teeth work into each other, and thus break the wood across, while the yielding fibre is not injured.

By the operation of heckling a threefold object is gained. 1st. The parting of the filaments into their finest fibrils; 2d. The separation of short fibrils, which are unfit for spinning; 3d. The equable and parallel arrangements of long filaments. The instrument for accomplishing these was a tool called the *heckle;* a surface studded more or less thickly with metal points called heckle teeth: over which the flax is drawn in such a way that the above three required operations may be properly accomplished. The operation is simple, but requires expertness to work well. The operative seizes a flock of flax by the middle with the right hand, throws it on the points of the coarse heckle, and draws it to him, while he holds the left hand on the other side of the heckle, so as to spread the flax, and to prevent it from sinking too deeply among the teeth. The short fibres, or tow, are removed occasionally. When one half the length of the strake of flax is heckled, it is turned to heckle the other half. 100 lbs. of well cleaned flax, 45 or 50 lbs. of heckled flax, may be obtained by hand labor of 50 hours; the rest being tow, with a small waste of fibre of wood. Machinery has not yet been made to effectually supersede hand labor in heckling. To aid the heckle in splitting the filaments, three methods have been had recourse to. 1. Beating, brushing, and boiling with soap water or an alkaline ley. This boiling dissolves that portion of the glutinous cement which had resisted the rotting, and completes the separation of the fibres, and is an excellent plan of improving flax. Machines driven by steam have been employed for the heckling, combing, and scutching of the fibres. Scutching is effected in the heckling machine by means of four arms projecting from a horizontal axle arranged so as to strike the boom in a slanting direction, until the bark and other useless parts of the plant are beaten away.

In the spinning of flax, compared with cotton and wool, it possesses several characteristic properties. While cotton and wool are naturally presented as insulated fibres, the former requiring to be merely separated from the seed, and the latter to be purified before delivery to the spinner, flax must have its filaments separated from each other by tedious treatment. In reference to the spinning and subsequent operations, it may be said that good flax should have a bright silver gray, or yellow color, inclining neither to green or black. It should be long, firm, soft, and glistening, like silk, and contain no broad, tape-like portions from undissevered filaments. Tow is different in having shorter fibres of very unequal length, and entangled.

The manufacture of linen and hemp yarn, and the tow of either, may be effected by different processes; by the distaff, the hand-wheel, and spinning machinery. In the language of flax mills, the flax ceases to be so called after it has passed through the heckling machine. The great portion is then called *line*, and the inferior *tow*. Both of these are afterwards spun into yarn, but the yarn so produced has different degrees of excellence. Other machines are used, by which tow is converted into *slivers*, by carding analogous to cotton and wool processes.

When the slivers, whether of *line* or *tow*, have been brought to the desired breadth, thickness, and equality, they are carried to the 'roving machines,' where they are transformed to the state of a soft, small, cylindrical cord. There are two combined movements whereby this is effected; the sliver is drawn out or elongated, and it has a slight twist imparted to it as a means of enabling it to cohere and to bear the subsequent action of the spinning-machines.

These spinning-machines we have next to notice. They are on the 'bobbin-and-fly' principle; 'mule-spinning' not having, we believe, been introduced in the flax manufacture. Flax, unlike cotton, silk, wool, or worsted, is spun wet, as a means of obtaining a finer and smoother yarn; and within the last few years the use of warm water, instead of cold, has been introduced for this purpose. The same flax, prepared in the same way, can be spun to a much higher number, or much greater degree of fineness, with hot water than with cold; and this is doubtless one of the improvements to which the recent progress of the flax manufacture may be attributed. The spindles by which the yarn is spun revolve some thousands of times in a minute, and the wet yarn thus throws off a continuous spray by the centrifugal force thereby generated; the girls and young women who attend the machines wear therefore a thick apron to protect themselves from the spray. The water is contained in a kind of oblong trough attached to each machine, and steam is admitted by a small pipe as a means of bringing the water to the required temperature.

When the yarn is spun, it is destined either for weaving or for thread. If for weaving, the yarn is reeled into hanks on a hexagonal reel, to be afterwards made up into bundles of twenty hanks each, containing sixty thousand yards; but if the yarn is to be made into thread, it is carried to other machines, by means of which two yarn-threads are twisted together, and converted into the hard and firm thread used in needlework and lace-making.

Here, then, the operations of a flax-mill terminate. If the flax-yarn is woven into any kind of linen or flaxen fabric, that is an additional feature. At most flax-mills the operations cease when the yarn and thread are produced.

FLEXIBILITY. That property of bodies in virtue of which, when a sufficient force is applied to them, they change their form, and are bent. Flexibility is opposed to stiffness on the one hand, and to brittleness on the other; stiff bodies being such as resist bending, and brittle those that cannot be bent without a disruption of their parts.

FLINT. Common flints are nearly pure *silica*. They usually occur in irregular nodules in chalk. Their origin is an unsolved geological problem.

FLINT GLASS, or CRYSTAL. A species of glass which derives its name from flint, because that substance was formerly employed in its manufacture. It is very extensively used for domestic purposes; but is chiefly interesting to the philosopher on account of the property which it possesses of causing a greater dispersion of the rays of light which pass through a prism or lens formed of it than any other of the vitreous compounds. This property renders it invaluable in the manufacture of the object glasses of telescopes and microscopes; for by combining a concave lens of flint glass with one or two convex lenses of *crown glass*, which possesses a much less dispersive power, a compound lens is formed, in which the prismatic colors arising from a simple refraction are destroyed, and the lens rendered achromatic. This construction of object glasses was first discovered by a Mr. Hall, a country gentleman in Worcestershire, about 1729; but the discovery was forgotten, and no farther notice taken of it for nearly 30 years, when it was again brought to light by John Dollond, after a long-continued course of experiments undertaken for the purpose of perfecting the telescope. It is, however, very difficult to prepare flint glass fit for the purposes of achromatic telescopes. This difficulty arises not from the want of sufficient dispersive power in the substance, but from the want of purity or homogeneity; the slightest impurity or inequality of composition in the glass giving rise to a streaked or imperfect image by reason of the unequal refraction of the rays. The composition of pure flint glass long remained a secret in the family of the Dollonds, and its manufacture formed a very profitable article of exportation; for till about the beginning of the present century, no flint glass of good quality was made on the Continent. Of late years, however, a great change has taken place in this respect, and glass of the best quality has been manufactured, both in France and Germany, in much larger masses than the English artists have yet succeeded in obtaining. This result has been mainly produced by the experimental researches of D'Artigues, Fraunhofer, Cauchoix, Guinand, and Korner. Formerly, an object-glass exceeding five inches in diameter could scarcely be produced. Fraunhofer succeeded in making them of nine, and even twelve inches. The object-glass of the large parallactic telescope belonging to Sir James South, at Campden Hill, was manufactured by Cauchoix; it exceeds twelve inches, and is throughout of the utmost purity. The exact proportion of the ingredients which enter into these choice specimens is not known, and probably their excellence depends in part on some accidental circumstances in the preparation. Korner produced some of his best specimens by employing the following ingredients: 100 parts of quartz, first treated with muriatic acid; 80 parts of litharge, or red lead; and 80 parts of the bitartrate of potash. Flint glass for common purposes is usually made of 120 parts of fine white sand, 40 parts of well purified pearl ash, 35 parts litharge or minium, 13 parts nitre, and a small quantity of the black oxide of manganese; the latter ingredient being used to correct the green color occasioned by the presence of oxide of iron in the sand.

FLINT-GRINDING is a mechanical process indispensable in the manufacture of earthenware and porcelain. The flint nodules, derived from the chalk formations, are calcined in small kilns (formed similarly to lime-kilns). While hot they are thrown beneath the *stampers*, a set of vertical beams, whose ends are shod with iron, and which are lifted up by the crank or shaft, and fall on the nodules, the fractured portions falling through a grate.

These are thrown into a circular vat, 10 to 15 feet in diameter, the bottom paved with blocks of chert-stone, the hornstone of Jameson. In a step in the centre is placed the axis of a vertical strong wooden shaft, on the upper end of which is a crown spur-wheel, for the requisite motion from a steam-engine or water-wheel. At right angles this shaft has an arm, each with a ledge, to bear other blocks of chert. The whole being put in motion, the abrasure of the calcined flints is promoted by that of the chert among the water, and is continued until the mass is a pulpy fluid, and a pint measure of it weighs not less than 32 oz. The Cornish stone is ground in a similar manner, and the pulpy fluid is not less than 33 oz. the pint measure. One ton of good nodules should grind into 120 pecks of flint pulp.

Flints are also reduced to fine powder, by heating them red hot and quenching them in water.

FLOAT BOARDS. The boards fixed to the rim or outer circumference of undershot wheels, which receive the impulse of the water and communicate the motion to the wheel.

FLOATED LATH AND PLASTER. In architecture plastering of three coats, whereof the first is pricking up; the second, floating or floated work; and the last of *fine stuff*.

FLOATED WORK. In architecture, plastering made of a perfectly plane surface, by means of a tool (which is a long rule with a straight edge) called a float.

FLOATING MEADOWS. Meadow lands, the surface of which is flat, adjoining a river or other source of water, with which they can be flooded or covered at pleasure. The water is turned on chiefly in the winter season, when it is more or less muddy, and leaves a deposit that serves as a kind of manure. It is also useful to vegetation, by preserving a higher temperature in the surface soil than it could maintain through the winter, if fully exposed to the action of the atmosphere; because, wherever water is in a fluid state, its mean temperature, and that of the bodies immediately in contact with it, must be above 32°, and at that temperature the grasses common in British meadows will grow. There are probably other benefits which grass lands receive from being covered with water during a portion of the winter season, but these have not yet been satisfactorily explained by science.

FLOATING SCREEDS. In architecture, strips of plaster arranged and nicely adjusted for guiding the *floating-rule*. *See* Floated Work.

FLOATSTONE. A porous variety of flint, which floats upon water.

FLOSS-SILK is the name given to the portions of ravelled silk broken off in the filature of the cocoons, which is carded like cotton or wool, and spun into a soft coarse yarn or thread, for making bands, shawls, socks, and other common silk fabrics. The floss or fleuret, as first obtained, must be steeped in water, and then subjected to pressure, in order to extract the gummy matter, which renders it too harsh and short for the spinning-wheel. After being dried, it is made still more pliant by working a little oil into it with the hands. It is now ready to be submitted to the carding engine. It is spun upon the flax wheel.

FLOUR OF WHEAT (ADULTERATIONS OF, TO DETECT). The first method is by specific gravity. If potato flour be added, which is frequently done in France, since a vessel which contains one pound of wheat flour will contain one pound and a half of the fecula, the proportion of this adulteration may be easily estimated. If gypsum or ground bones be mixed with the flour, they will not only increase its density still more, but they will remain after burning away the meal.

The second method is by ascertaining the quantity of gluten which the suspected sample will afford, by the process prescribed under the article BREAD. The two following chemical criteria may also be employed.

1st. Nitric acid has the property of coloring wheat flour of a fine orange yellow, whereas it affects the color neither of fecula nor starch.

2d. Pure muriatic acid colors good wheat flour of a deep violet, but dissolves fecula or starch, and forms with it a light, colorless, viscous fluid, decomposable by alkalis. It may also be observed, that as fecula absorbs less water than flour, this affords a ready means of detection.

The adulteration with bean or pea flour may be detected by pouring boiling water upon it, which develops the peculiar smell of these two substances.

FLOWERS (ARTIFICIAL). The art of representing by flowers, leaves, plants, &c., vegetable nature in her ornamental productions, constitutes the business of the artificial florist. The Italians appear to have been the first in modern Europe who excelled in the art of making artificial flowers, but of late years the French have been most ingenious [illegible] [illegible] R[illegible] [illegible] were [illegible] employed for [illegible] [illegible] the way to [illegible] and [illegible] of assuming a variety of flower-like figures. But a great difficulty was encountered in dyeing them with due vivacity. The savages of South America manufacture perfect feather flowers, derived from the brilliant plumage of their birds, which closely resemble the products of vegetation. The blossoms and leaves are admirable, while the colors never fade. The Italians employ frequently the cocoons of the silkworm for this purpose; these take a brilliant dye, preserve their color, and possess a transparent velvety appearance, suitable for petals. Of late years, the French have adopted the finest cambric for making petals, and the taffeta of Florence for the leaves.

Tissue paper, twisted on wire, constitute the stem and branches. The leaves are made from muslin, cambric, velvet, and gold and silver lama muslin, which are stamped out with a die, having the form and outline of the leaf. The flowers are made from velvets and muslin stamped out as the leaves, and tinted with transparent colors; occasionally the fine variations on the surface are painted with pencil and paint.

The greater amount of artificial flowers, and the richer kinds, are imported from France. The manufacture of the common kinds in this country is, however, very extensive.

M. de Bernardiere employs whalebone in very thin leaves for artificial flowers; and by bleaching and dyeing them of various colors, he has succeeded in making his imitations of nature to be very remarkable.

The coloring matters used in flower dyeing are the following:

For red: carmine dissolved in a solution of salt of tartar, or in water of ammonia.

For blue: indigo dissolved in sulphuric acid, diluted and neutralized in part by Spanish whitening or chalk.

For bright yellow: a solution of turmeric in spirit of wine. Cream of tartar brightens all these colors.

For violet: archil, and a blue bath.

For lilach: archil.

Some petals are made of velvet, and are colored merely by the application of the finger dipped in the dye.

FLUATES, more properly *fluorides*, compounds of fluorine and the metals, as fluor spar, for example, which consists of fluorine and calcium.

FLUKE is also applied in navigation to the broad part of the anchor, which takes hold of the ground.

FLUOBORIC ACID. A gas obtained by heating to redness a mixture of dry boracic acid and powdered fluor spar. Its specific gravity is 2·36. It is colorless, pungent, and produces a dense white cloud when it escapes into a moist atmosphere; it is resolved by the action of water into boracic and hydrofluoric acids. It acts with great energy upon animal and vegetable substances, and chars them. It is probable a compound of 20 parts of boron and 108 of fluorine, or of one atom of boron and 6 atoms of fluorine.

FLUORIC ACID. *See* Hydrofluoric Acid.

FLUORINE. The hypothetical base of the hydrofluoric acid; it has not yet been obtained in a separate state.

FLUOR SPAR. This is a common mineral product, found in great beauty in Derbyshire; hence known in this country under the name of the *Derbyshire spar*. It is generally crystallized in cubes, but its primitive form is an octahedron. It is of various colors, and often beautifully banded, especially when in nodules, which are much prized for the manufacture of vases, and occasionally used for beads, brooch stones, and other ornamental purposes. It is probably a compound of fluorine and calcium, hence a *fluoride of calcium*. The term *fluor* is derived from the fusibility of this substance, on which account it is sometimes used as a flux to promote the fusion of certain refractory minerals. It is manufactured at Matlock and Derby into a great variety of articles. It abounds in N. Jersey.

FLUOSILICIC ACID. A gas obtained by applying a gentle heat to a mixture of one part of powdered fluor spar, one of silica, and two of sulphuric acid in a retort. It is colorless, pungent, fumes when it escapes into a humid air, and is rapidly absorbed by water. Its specific gravity is about 3·6; 100 cubic inches weighing nearly 112 grains. It is decomposed by water, and forms silica and hydrofluric acid. It consists of 8 parts by weight of silicium, and 18 of fluoride, its equivalent (upon the hydrogen scale) being 26.

FLUIDITY is that state of a substance in which its constituent particles are so slightly cohesive that they yield to the smallest impressions. The term is usually confined to express the condition of the nonelastic fluids; and hence it denotes one of the three states in which matter exists; namely, the solid, the fluid or liquid, and the gaseous. The state of fluidity is best defined as that in which bodies tend to form *drops*, as this disposition does not belong either to bodies in a gaseous form, or to solid bodies reduced to fine powder. The formation of drops arises from this, that the molecules of fluid bodies adhere to each other with a certain force, at the same time that they glide over one another without any sensible resistance. It is incorrect to say that the molecules of bodies in a state of fluidity offer no resistance to separation; for, on bringing a flat disc of glass or metal into contact with the surface of a liquid, a very sensible degree of force is required to separate them. That adhesion exists among the molecules of fluid bodies is also proved by various other phenomena. Water or mercury on a flat plate of metal collects in globules, and when slowly poured into a wine glass will remain heaped up, as it were, above the level of the edge.

Various hypotheses have been framed by philosophers to explain the different states in which matter is found to exist. Confining ourselves to the most general views, we may regard all bodies as assemblages of particles constantly maintained in equilibrium between two forces, an attractive force which tends to unite the particles, and a repulsive force which tends to increase the distance between them. The solid state results from the preponderance of the attractive force. Conceive the repulsive force to receive an augmentation until it becomes equal to, or forms an equilibrium with, the attractive force. When the two forces are thus balanced, the particles exert on each other neither attraction nor repulsion, and the body is in the fluid state. Lastly, if the repulsive energy be still increased, the particles will be separated from each other to such distances that their mutual attractions will cease altogether to be sensible, and then the body passes into the gaseous state. Hence we may pronounce that there is no *natural* state of body; and that fluidity, solidity, the state of vapor, and the aëriform state are only accidental, and determined by the temperature of the medium in which the body is placed.

FLUX. A substance which is mixed with metallic ores, or other bodies, to promote their fusion, just as an alkali is mixed with silica to form a glass. From the property which the borates possess of fusing metalic oxides, they are used by braziers, tinmen, &c. It is this salt which is chiefly used in the fusion of filature of the cocoons, which is carded like cotton or wool, and spun into a soft coarse yarn or thread, for making bands, shawls, socks, and other common silk fabrics. The floss or fleuret, as first obtained, must be steeped in water, and then subjected to pressure, in order to extract the gummy matter, which renders it too harsh and short for the spinning-wheel. After being dried, it is made still more pliant by working a little oil into it with the hands. It is now ready to be submitted to the carding engine. It is spun upon the flax wheel.

FLOUR OF WHEAT (ADULTERATIONS OF, TO DETECT). The first method is by specific gravity. If potato flour be added, which is frequently done in France, since a vessel which contains one pound of wheat flour will contain one pound and a half of the fecula, the proportion of this adulteration may be easily estimated. If gypsum or ground bones be mixed with the flour, they will not only increase its density still more, but they will remain after burning away the meal.

The second method is by ascertaining the quantity of gluten which the suspected sample will afford, by the process prescribed under the article BREAD. The two following chemical criteria may also be employed.

1st. Nitric acid has the property of coloring wheat flour of a fine orange yellow, whereas it affects the color neither of fecula nor starch.

2d. Pure muriatic acid colors good wheat flour of a deep violet, but dissolves fecula or starch, and forms with it a light, colorless, viscous fluid, decomposable by alkalis. It may also be observed, that as fecula absorbs less water than flour, this affords a ready means of detection.

The adulteration with bean or pea flour may be detected by pouring boiling water upon it, which developes the peculiar smell of these two substances.

FLOWERS (ARTIFICIAL). The art of representing by flowers, leaves, plants, &c., vegetable nature in her ornamental productions, constitutes the business of the artificial florist. The Italians appear to have been the first people in Europe who excelled in the art of making artificial flowers; but of late years the French have been most ingenious in this branch of industry. Ribbons folded in different colors were originally employed for imitating flowers, by being attached to wire stems. This imitation soon gave way to that of feathers, which are more delicate in texture, and more capable of assuming a variety of flower-like figures. But a great difficulty was encountered in dyeing them with due vivacity. The savages of South America manufacture perfect feather flowers, derived from the brilliant plumage of their birds, which closely resemble the products of vegetation. The blossoms and leaves are admirable, while the colors never fade. The Italians employ frequently the cocoons of the silkworm for this purpose; these take a brilliant dye, preserve their color, and possess a transparent velvety appearance, suitable for petals. Of late years, the French have adopted the finest cambric for making petals, and the taffeta of Florence for the leaves.

Tissue paper, twisted on wire, constitute the stem and branches. The leaves are made from muslin, cambric, velvet, and gold and silver lama muslin, which are stamped out with a die, having the form and outline of the leaf. The flowers are made from velvets and muslin stamped out as the leaves, and tinted with transparent colors; occasionally the fine variations on the surface are painted with pencil and paint.

The greater amount of artificial flowers, and the richer kinds, are imported from France. The manufacture of the common kinds in this country is, however, very extensive.

M. de Bernardiere employs whalebone in very thin leaves for artificial flowers; and by bleaching and dyeing them of various colors, he has succeeded in making his imitations of nature to be very remarkable.

The coloring matters used in flower dyeing are the following:

For red: carmine dissolved in a solution of salt of tartar, or in water of ammonia.

For blue: indigo dissolved in sulphuric acid, diluted and neutralized in part by Spanish whitening or chalk.

For bright yellow: a solution of turmeric in spirit of wine. Cream of tartar brightens all these colors.

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FLY. In mechanics, an appendage given to machines for the purpose of regulating and equalizing the motion, as in the windlass, jack, pile-engine, &c.; and sometimes for collecting force in order to produce a very great instantaneous impression, as in the coining press. Generally it is formed of a heavy disc or hoop at right angles to the axis; sometimes of heavy knobs at the extremities of a bar having the same position. The fly is of great use in all cases where the power, or the resistance, acts unequally in the different parts of a revolution.

FLYING BUTTRESS. In Gothic architecture, a buttress in the form of an arch, springing from a solid mass of masonry, and abutting against the springing of another arch which rises from the upper points of abutment of the first. It is seen in most ancient cathedrals, and its office is to act as a counterpoise against the vaulting of the nave. If flying buttresses were built solid from the ground, it is obvious that they would interfere with the vista along the aisles of the church; hence the project of continuing a resistance by means of arches. Their stability depends on the resistance afforded by the weight of the vertical buttress from whence they spring.

FLY POWDER. An imperfect oxide of arsenic, formed by the exposure of native arsenic to the air: when mixed with sugar and water it is used to kill flies.

FOIL. A term generally applied to a varnished metal. Common foil is thus made: a copper plate covered with a thin layer of silver is rolled out into sheets under the flatting mill. The silver surface is then highly polished, or covered with a colorless varnish. The colored foils are similarly prepared with colored varnishes.

FOOD. All substances susceptible of digestion and assimilation may come under the denomination of *food*; but the proximate principles of organic bodies on which their nutritive powers depend are comparatively few. Hence, although, the articles employed in different countries for the support of animal life are almost infinitely various, their sustaining powers may be referred to certain substances capable of being separated and identified by chemical analysis and tests. Among the proximate elements of vegetable food gluten and its modifications, starch, gum, sugar, oil, wax, and lignin or woody fibre, are by far the most important; and among those of animal food albumen, gelatin, and their modifications, together with fats and oils, which are common to both kingdoms of nature.

To illustrate the actual simplicity of our food as compared with its apparent multifariousness and complexity, it may suffice to state, that wheat and almost all the esculent grains consist principally of starch and gluten; that the same ingredients are found in many fruits and roots; that sugar, gum or a relation of gum which is called vegetable jelly, together with minute traces of aromatic principles which give flavor, and more or less abundance of water, and of vegetable acids, are the chief component parts of apples, pears, peaches, currants, gooseberries, and all analogous tribes of fruits; a very few also contain oil. Then, as regards *animal* food, the muscular fibres of various animals closely resemble each other in composition and nutritive power; in some cases texture merely, and in others minute additions of foreign matters, confer upon them their relative digestibilities, and their different aspects and flavors; albumen or fibrine, and gelatin, small proportions of saline bodies, and a large quantity of water are found in them all.

It often happens that the truly nutritious part of food is so combined with or protected by indigestible matters, as to escape the solvent powers of the stomach, unless previously prepared and modified by various chemical and mechanical agents. Indurated woody fibre, for instance, or *lignin*, as chemists call it, will often resist the joint action of the stomach and bowels, and pass through the alimentary canal with scarcely any alteration. The husks of many seeds and fruits are composed almost exclusively of this material. This is the case with the kernels of the apple, pear, &c.; the seeds of the currant, gooseberry, melon, and so on; the skin or husk of peas, beans, &c., and of wheat, barley, and oats; so that unless the woody part is either broken down by the teeth or previously removed, the food which it envelops is protected from the solvent action of the secretions of the stomach. This is in some respects a wise and curious provision in nature; for birds in this way become the carriers of seeds, which pass through them not only undigested, but even retaining their vegetative powers; and in this way uninhabited and sterile portions of the globe may gradually become clothed with verdure, and shrubs, and trees. Bones are highly nutritive; but unless broken into very small fragments by the masticatory powers of the animals which eat them, they too would elude digestion. In reference, however, to the food of man, much of its digestibility and nutritious power is referable to the important chemical operations preparatory to its use which are carried on in the kitchen; in other words, cookery is essentially a chemical art; and substances totally unfit, in their raw state, for reception into the stomach, are rendered palatable, digestible, and nutritious by the skill of the cook. And here salt, and a variety of *condiments*, as they are called, and which are aromatic and stimulant substances, chiefly of vegetable origin, play an important part; nor must the mere effect of heat be overlooked, for it is most important. Meat, by boiling and roasting, is not only softened in its fibre, but new substances are generated in it. Among these a peculiar extractive matter, and *osmazone*, or the principle which gives an agreeable flavor and odor to dressed meat, are especially recognized. Nor are the changes which vegetables suffer under the influence of heat less obvious.

There is another important point in the history of our food, namely, its *ultimate composition*. We have spoken of starch, sugar, gum, albumen, and other substances as the *proximate* principles upon which we live; but what is the *ultimate* constitution of these secondary products, what are their true *elements?* It is curious that four *elements* only are principally concerned in the production of our food. These are, carbon, hydrogen, oxygen, and nitrogen. Among vegetable substances gluten (including vegetable albumen) is the only one which abounds in nitrogen; gum, sugar, starch, and the rest are constituted of carbon, hydrogen, and oxygen only; and what is very remarkable is, that in all these important principles, and also in lignin, the oxygen and hydrogen bear to each other the same relative proportions as in water, so that they may be figuratively, perhaps truly, described as compounds of *charcoal* and *water*. Now there are two very curious points in reference to that part of the chemical history of our food which has been adverted to; the one is, that no animal can subsist for any length of time upon food which is destitute of nitrogen; and the other, that a certain mixture of different kinds of food is absolutely essential. An animal fed *exclusively* on starch, or sugar, or albumen, or jelly, soon begins to suffer in health; peculiar diseases make their appearance, and his existence is painful and brief; but mix these together and occasionally modify their proportions, and he then thrives and fattens. Magendie's experiments on this subject, together with those of Tiedemann and Gmelin, well illustrate this fact. Thus, geese fed upon gum died on the 16th day, those fed upon starch on the 24th, and those fed on the boiled white of egg on the 46th; in all these cases they dwindled away and died as if from starvation.

Habit, as is well known, will do much in accustoming the stomach to particular descriptions of food; many persons live exclusively, or almost so, on vegetable, others on animal matters, and particular kinds of diet are forced on the inhabitants of many regions of the globe; but, as far as we are concerned, a due mixture of vegetable and animal matter is not only most palatable, but most conducive to health. The variety in our teeth and the structure of the alimentary canal, point out a mixed food as the most appropriate. The shortness of the intestinal canal shows that man was not intended to live solely on vegetable diet.

Nothing is fit for food which has not already undergone organization; and *water*, though an essential part of the food of all animals, is obviously not in itself nutritious, though it performs the extremely important function of dissolving nutritive matter, so as to render it conveyable by the lacteals and other absorbents into the blood. No compound then of nitrogen, hydrogen, carbon, and oxygen, which can be formed artificially, can constitute food. Air, water, and charcoal, though involving the *elements* of our nutriment, are themselves unfit for our support; and it is only by passing through the hidden processes which are carried on in the vessels of living things, that they are so recombined and modified as to be rendered capable of supporting animal life. It is the vegetable world which commences this wonderful operation. Plants absorb their nutriment from the air and from the soil; they assimilate in-

inorganic as well as organic matter; they become the food of the graminivorous tribes, and from these man derives the great bulk of his animal food. Animals cannot create food; they cannot form any one of these proximate principles we have mentioned; this is the office of the plant. The plant is a creating being, the animal only assimilates what the plant had formed.

In speaking of the composition of food, that of *milk*, the most important of all food, must not be forgotten; in it nature has wonderfully provided a mixture which, though secreted by an animal, partakes also of the nature of vegetable food, and it presents a perfect analogy to that combination of vegetable and animal matter which has been mentioned as most congenial to the palate and stomach. The albumen or *curd* of milk is a highly elaborated animal principle, abounding in nitrogen, yet, from its attenuated and soluble state, easy of digestion. A second principle of milk is what is termed *sugar of milk*; in composition and properties it resembles a vegetable product, and is intermediate between gum and sugar. The third component of milk is *butter*, partaking of the nature of vegetable oil and animal fat; there are certain saline and acid substances in small proportion; and all these matters are either dissolved or suspended in a large relative proportion of water.

I. Table showing the average quantity of nutritive matter in 1000 *parts of several varieties of animal and vegetable food.*

Blood	215	Beef	260
Veal	250	Mutton	290
Pork	240	Brain	200
Chicken	270	Cod	210
Haddock	180	Sole	210
Bones	510	Milk	72
White of egg	140	Wheat	950
Rice	880	Barley	920
Rye	792	Oats	742
Potatoes	260	Carrots	98
Turnips	42	Cabbage	73
Beet root	148	Strawberries	100
Pears	160	Apples	170
Gooseberries	190	Cherries	250
Plums	290	Apricots	260
Peaches	200	Grapes	270
Melon	30	Cucumber	25
Tamarind	340	Almonds	650
Morels	896		

The above table represents the relative proportions of solid digestible matter contained in 1000 parts of the different articles of food which are enumerated. When blood, for instance, is evaporated to dryness, at a temperature not exceeding 212°, the residue amounts to 215 parts in 1000, and may be regarded as almost entirely composed of digestible matters; it consists of albumen and coloring matter, with small proportions of saline substances. The different kinds of meat were dried in the same way. The loss of weight during their desiccation is almost wholly referable to water; and the dry residue composed of albumen or fibrine, with some gelatine, and perhaps traces of fat and of saline matters, represents the true nutritive value. Upon an average, therefore, the nutritive matter in a pound of meat is not more than four ounces. This, however, only applies to raw meat; for when dressed a considerable portion of its constituent water is often dissipated. The nutritive matter of wheat is chiefly starch and gluten, and in this species of grain the gluten is in much greater relative proportion to the starch than in barley, oats, or rye. In rice there is little else than starch. There can be little doubt that the great value of wheat as an article of food depends upon this excess of gluten, which is a nitrogenous substance, and has not inaptly been termed the vegeto-animal principle. In the esculent roots, such as carrots, &c., but especially turnips, sugar is the leading nutritive matter; and the common fruits contain sugar, gum, albuminous matter, and acids, together with a highly attenuated form of woody fibre, or lignin, which, in that state, is probably digestible.

The following table shows the ultimate composition of those proximate principles which have been above adverted to as constituting the nutritive part of food.

II. Table showing the ultimate elementary composition in 1000 *parts of the following proximate principles in animal and vegetable food.*

	CARBON.	HYDROGEN.	OXYGEN.	NITROGEN.
Albumen	516	76	258	150
Gelatin	483	80	276	161
Fat	780	122	98	
Curd of milk	609	73	116	208
Sugar of milk	454	61	485	
Gluten	557	78	220	145
Starch	438	62	500	
Gum	419	68	513	
Sugar	444	62	494	
Lignin	500	56	444	

Tables like the above have been used to point out the nutritive *values* of food; those which contain the greatest amount of nitrogen being esteemed the most nutritious; this view must not, however, be too hastily adopted. If the nitrogen exist in the form of albumen, gluten, fibrin, or casein, any of the forms of what Mulder has termed Protein, the composition of which is, carbon 54·37, hydrogen 7·12, nitrogen 15·93, and oxygen 22·58, in 100 parts, it is undoubtedly true. But many substances contain nitrogen in other forms, as the mushroom tribe; in these it exists as ammonia, which does not in any way contribute to the nutrition of an animal. Such substances therefore have not a nutritive value at all equal to what the percentage of nitrogen in them would indicate.

The uses of these proximate principles to the animal frame are different. The substances containing nitrogen go to form the solid parts of the blood and muscle of the animal; the starch, gum, and sugar assist in respiration and in producing animal heat; the oils and fat serve the same end, and are occasionally stored up as fat in the animal frame to meet the wants of the system when it may require it.

FORCE, in mechanics, denotes that combination of matter and motion which produces a change in the state or position of a body. According to this definition, the muscular power of animals, as likewise pressure, impact, gravity, &c., are considered as effects of motion in other bodies; it being evident, from daily experience, that bodies exposed to any free action have force imparted to them, or are themselves thereby imbued with power. All forces, however various, are measured by the effects which they produce in like circumstances, whether the effect be creating, accelerating, retarding, or deflecting motions.

When we say that a force is represented by a right line, A B, it is to be understood that it would cause a material body, situated at A, to run over the line A B, which is called the direction of the force, so as to arrive at B at the end of a given time, while another force would cause the same body to have moved a greater or less distance from A in the same time.

The force of a body in motion is a power residing in that body, so long as it continues its motion; by means of which, it is able to move other bodies lying in its way, or to lessen, destroy, or overcome the force of any other moving body, which meets it in an opposite direction; or, to surmount the largest dead pressure or resistance.

Force is quantity by velocity, before or after impact; and if quantity is increased, velocity is diminished. Nature and art is a display of the transfer and reception of force, *ad infinitum*, and what is lost by one body, is gained by other bodies, by these transferred again, and sometimes collected or concentrated, and at other times scattered and diffused. To trace the sources and distribution, is to analyze nature; but it is the most general of all laws, that wherever there is force, there is some matter, in some fit motion; and wherever there is matter in motion, there is resulting force.

Of course, there are no innate, or miraculous forces—no attraction—no repulsion—no elastic force—no vital force—all are derived from previous motions in other bodies, and the phenomena depend on the quantities of the agents and patients, on the direction of their velocity, and on various reactions.

Composition of forces takes place when two or more forces, differently directed, act upon the same body at the same time. As the body then cannot obey them all, it will move in a direction somewhere between their line. This is called the *composition* and *resolution* of forces or of motion. But, if the body be impelled by equal force, acting at right angles to each other, it will move in the diagonal of a square, and instances in nature, of motion produced by several powers acting at the same time, are innumerable.

All machines are impelled either by the exertion of animal force, or by the application of other powers of nature. The latter comprise the elements of water, air, and fire. The former is more common, yet so variable as hardly to admit of calculation. It is derived from the muscular lever of the animal acting against the ground, and the power of the muscles to act is derived from the gas fixed by respiration. It depends not only on the vigor of the individual, but on the different strength of the particular muscles employed. Every animal exertion is attended by fatigue of the muscles; it soon relaxes, and would speedily produce exhaustion. The most profitable mode of applying the labor of animals is to vary their muscular action, and revive its tone by short and frequent intervals of repose. The ordinary method of computing the effects of human labor is, from the weight which it is capable of elevating to a certain height, in a given time, the product of these three numbers expressing the absolute quantity of performance. This was reckoned by Bernoulli and Desaguliers, at 2,000,000 lbs. avoirdupois, which a man could raise one foot in a day. But, our civil engineers have gone much further, and are accustomed, in their calculations, to assume that a laborer will lift 10 lbs. to a height of 10 feet every second, and is able to continue such exertion for 10 hours each day, thus accumulating the performance of 3,600,000 one foot.

Coulomb has furnished the most accurate and varied observations on the measure of human labor. A man will climb a stair, of from 70 to 100 feet high, at the rate of 45 feet in a minute. Reckoning his weight at 155 lbs., the animal exertion for one minute is 6975 lbs., and would amount to 4,185,000, if continued for 10 hours. A person may clamber up a rock 500 ft. high, by a ladder-stair, in 20 minutes, and, consequently, at the rate of 25 feet each minute; his efforts are thus already impaired, and the performance reaches only 3875 in a minute. But, under the incumbrance of a load, the quantity of action is still more remarkably diminished. A porter, weighing 140 lbs., was found willing to climb a stair, 40 ft. high, 266 times in a day; but he could carry up only 66 loads of firewood, each of them 163 lbs. weight. In the former case, his daily performance was very nearly 1,500,000; while, in the latter, it amounted only to 808,000.

The quantity of permanent effect was hence only about 700,000, or scarcely half the labor exerted in mere climbing. In the driving of piles, a load of 42 lbs., called the *ram*, is drawn up 3½ ft. high 20 times in a minute; but the work has been considered so fatiguing, as to endure only three hours a day. This gives about 530,000 for the daily performance. Nearly the same result is obtained by computing the quantity of water, which, by means of a double bucket, a man drew up from a well. He lifted 36 lbs. 120 times in a day, from a depth of 120 ft., the total effect being 518,400. A skilful laborer, working in a field with a large hoe, creates an effect equal to 728,000. When the agency of a winch is employed in turning a machine, the performance is still greater, amounting to 845,000. In all these instances, a certain weight is heaved up, but a much smaller effort is sufficient to transport a load horizontally.

A man could, in the space of a day, scarcely reach an altitude of two miles, by climbing up a stair, though he will easily walk over 30 miles, on a smooth and level road. But he would, in the same time, carry 180 lbs. only to the fourth part of that distance, or 7½ miles. Assuming his own weight to be 140 lbs., the quantity of horizontal action would amount to 42,768,000, or 28 times the vertical performance; but the share of it, in conveying the load, is 20,961,780, or about 80 times what was spent in its elevation. The greatest advantage is obtained by reducing the burthen to 102 lbs., the length of journey being augmented in a higher ratio.

According to some experiments of the late Mr. Buchanan, the exertions of a man in working a pump, in turning a winch, in ringing a bell, and in rowing a boat, are as the numbers 100, 167, 227, and 248.

A man's force, in fact, is such, that he can raise 10 lbs. 10 ft. in a second, for 10 hours in a day, or 100 lbs., or 10 imperial gallons, 1 ft. per second, or in 10 hours, (36,000 seconds) 3,600,000 lbs. one ft., or 360,000 gallons one ft.

The labor of a *horse* in a day is commonly reckoned equal to that of five men; but then he works only eight hours, while a man easily continues his exertions for ten hours. Horses, likewise, display much greater force in carrying than in pulling; and yet an active walker will beat them on a long journey. Their power of drawing seldom exceeds 144 lbs., but they are capable of carrying more than six times as much weight. With regard to the ordinary power of draught, the formula $(12-v)^2$, where v denotes the velocity in miles an hour, will perhaps be found sufficiently near the truth. Thus, a horse beginning his pull with the force of 144 lbs., would draw 100 lbs. at a walk of two miles an hour, but only 64 lbs. when advancing at double that rate, and not more than 36 lbs. if he quickened his pace to six miles an hour. His greatest performance would hence be made with the velocity of 4 miles an hour. The accumulated effort in a minute will then amount to 22,528. The measure generally adopted for computing the power of steam-engines is much higher, the labor of a horse being reckoned sufficient to raise, every minute, to the elevation of one ft., the weight of 32,000 lbs. Wheel-carriages enable horses, on level roads, to draw, at an average, loads about 15 times greater than the power exerted.

FORCER. In Mechanics, a solid piston applied to pumps for the purpose of producing a constant stream, or of raising water to a greater height than it can be raised by the pressure of the atmosphere. *See* PUMP.

FORGE. The workshop in which iron is hammered and shaped by the aid of heat. The term is generally applied to the places in which these operations are carried on upon the comparatively small scale; the great workshops in which iron is made malleable for general purposes being called a *shingling mill.* A common forge consists of the hearth or fireplace, which is merely a cavity in masonry or brickwork well lined with fine clay or brick, upon which the ignited fuel is placed, and upon the back or side of which a powerful blast of air is driven in through the nozzle of a double-blasted bellows, which, in a common forge, is generally worked by a hand lever. Forges are sometimes constructed so as to be portable, when the bellows is most conveniently placed under the hearth: these are used in ships, and for various jobs on railways, &c.

FORMIC ACID. A sour liquor which ants eject when irritated, and which was formerly obtained by bruising the insects and distilling them, mixed with water; a peculiar volatile acid passed over. It has been ascertained by Dobereiner, that an analogous acid may be artificially obtained by distilling, from a capacious retort, a mixture of 2 parts of tartaric acid, 3 of peroxide of manganese, and 3 of sulphuric acid diluted with 5 of water. The tartaric acid acquires oxygen from the oxide of manganese, and is resolved into water, carbonic acid, and formic acid. From the analysis by Berzelius, of formiate of lead, it appears that formic acid is a compound of 2 atoms of carbon, 3 of oxygen, and 1 of hydrogen; or of 2 atoms of carbonic oxide, and 1 of water.

This acid decomposes the salts of a few metals. Silver is readily thrown out in the state of bright metal on glass surfaces, by means of formic acid.

FOUNDING, OF IRON. The operations of an iron foundry consist in remelting the pig-iron of the blast furnaces, and giving it an endless variety of forms, by casting it in moulds of different kinds, prepared in appropriate manners. Coke is the only kind of fuel employed to effect the fusion of the cast-iron.

The essential parts of a well-mounted iron foundry are,

Magazines for pig-irons of different qualities, which are to be mixed in certain proportions, for producing castings of peculiar qualities; as also for coal, coke, sands, clay, powdered charcoal, and cow-hair for giving tenacity to the loam mouldings.

One or more coke ovens.

A workshop for preparing the pattern and materials of the moulds. It should contain small edge millstones for grinding and mixing the loam, and another mill for grinding coal and charcoal.

A vast area, called properly the foundry, in which the moulds are made and filled with the melted metal. These moulds are in general very heavy, consisting of two parts at least, which must be separated, turned upside down several times, and replaced very exactly upon one another. The casting is generally effected by means of large ladles or pots, in which the melted iron is transported from the cupola, where it is fused. Hence, the foundry ought to be provided with cranes, having jibs movable in every direction.

A stove in which such moulds may be readily introduced as require to be entirely deprived of humidity, and where a strong heat may be uniformly maintained.

Both blast and air furnaces, capable of melting speedily the quantity of cast-iron to be employed each day.

A blowing machine to urge the fusion in the furnaces.

The mode of casting metal pipes will serve to illustrate many different varieties of iron-founding. There is formed, in the first place, a core or central pattern of cast-iron, with alternate grooves and ridges extending from end to end. Round this is wrapped a covering of hay or straw rope, and this rope is plastered with a layer of wet loam or clay, worked until the exterior surface becomes cylindrical, and corresponding in diameter with the internal dimensions of the pipe to be made. From this mode of formation it follows that there are hollow channels or gutters beneath the straw-rope, and these serve for the exit of heated air in the subsequent processes. The core, when formed, is sprinkled with powdered charcoal, and placed in a heated oven to harden. Meanwhile, the mould for giving the external form of the pipe is being prepared. A model, or pattern, is made, corresponding exactly with the exterior of the pipe to be made, and with this pattern a mould, or cavity, is formed in a smooth bed of sand, in two halves. Then, when the core is placed and supported concentrically in this mould, there is a cylindrical space between the two, equal to the thickness of the intended pipe. Holes for the admission of the melted metal, and others for the exit of the heated air, are provided, and the metal is poured in from the ladles or vessels before alluded to. It will be plain, on a little consideration, that the exterior of the core must give the interior form to the pipe, while the interior of the mould must give the exterior form to the pipe.

In casting pipes of large diameter, the core and mould are built up vertically in a pit as deep as the pipes are long; and matters are so arranged that the liquid metal is poured in at one end. In casting large cylinders for steam-engines and other purposes, the formation of the mould and core is a matter of much importance; each being formed of brick-work built up cylindrically, and of such dimensions that the larger may inclose the former, leaving a space between them equal to the intended thickness of the metal cylinder. The outer surface of the inner cylinder, or core, and the inner surface of the outer cylinder, or mould, are wrought very smooth and regular; and both cylinders being adjusted in a pit, melted metal is poured into the vacuity between them. Thus is the cylinder formed. The process of *boring*, to which such cylinders, as well as cannon and other articles requiring a smooth interior, are afterwards subjected, is not, as the name seems to imply, the boring or making a hole, but a planing, scraping, or cutting away of the inner surface, till it becomes regular and smooth from end to end.

In all large specimens of casting, such as bed-plates for marine engines, arches for bridges, beams for roofs, plates for large cisterns and tanks, turn-tables for railways, framework for engines and machines of various kinds, and such like, the mould is made in sand on the floor of the casting-house, from moulds or patterns previously constructed in accordance with the working drawings, and the liquid metal is poured into these moulds at once from the blast-furnace, or from the ponderous vessels, or from a cupola-furnace, according to the circumstances of the case.

FOUNT, or FONT, among printers, &c.; a set of types, sorted for use, that includes running letters, large and small capitals, single letters, double letters, points, commas, lines, numerals, &c.; as a fount of English, of Pica, of Bourgeois, &c. A fount of 100,000 characters, which is a common fount, would contain 5000 types of *a*, 8000 of *c*, 11,000 of *e*, 6000 of *i*, 3000 of *m*, and about 30 or 40 of *k*, *x*, *y*, and *z*. But this is only to be understood of the lower-case types; those of the upper-case having other proportions.

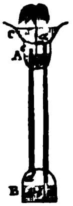
A small fount may consist of fifty or one hundred pounds weight, comprising the usual proportion of the various letters of the alphabet; and a large fount, of thirty or forty thousand pounds weight, or more.

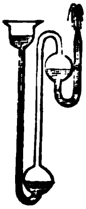
FOUNTAIN. By this term is designated any natural or artificial apparatus by means of which water springs up. In natural fountains the ascensional effort is produced by the hydrostatic pressure of the water itself; in artificial fountains it is produced either by the same pressure, or by that of compressed air, or sometimes by machinery.

The theory of natural fountains is extremely simple: it depends on the well-known property of fluids, which when inclosed in tubes or vessels communicating with each other, the fluid rises to the same level in all of the tubes: the pressure on the sides of the tube at any point being equal to the height of the vertical column above the tube.

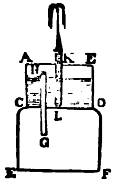
Now it is precisely on this principle that all natural fountains are explained. The rain which falls from the atmosphere is absorbed in three different ways. One part of it collects in rills on the surface of the ground; these unite in streams or rivulets, which flowing into one another form rivers, and thus it is conveyed to the ocean. A second part is taken up in giving humidity to the soil, from which it is returned to the atmosphere by evaporation. A third portion descends into the earth, through soils of a spongy or porous nature, or through crevices and interstices in the strata, until it meets, frequently at a very considerable depth, with strata through which it cannot penetrate, and is then collected in subterraneous reservoirs. When confined in this manner it is subject to the pressure of the water which fills the channels through which it has descended; and when this pressure is sufficient to overcome the resistance of the superincumbent mass of earth, the water breaks the artificial strata, and gushes forth in a spring. But if the strength of the superincumbent materials exceed the hydrostatic pressure, the water will remain stored up as it were in the subterraneous reservoir. Now if the ground above such a reservoir, or any channel communicating with it, be perforated, the water, having free access to the opening, will rise in it till it attains the level of the highest part of the channels from which it is supplied. If this level is above the surface of the ground, the water will have a tendency to rise; and when the ascensional force is considerable, it may by proper means be formed into a fountain. That subterraneous reservoirs formed in this manner exist in great abundance, and at great depths under the surface, we have sufficient evidence in the facility with which water may be obtained in almost all countries from *Artesian Wells.*

FOUNTAIN OF HERO. An ingenious hydraulic machine, ascribed to Hero of Alexandria, who lived 150 years B. C. Its principle depends on the transmission of the pressure sustained by a body of water in one vessel to that in another by means of the elasticity of air. The essential parts of the fountain consist of two close vessels, A and B. The one placed somewhat above the other, and connected by a frame; and having a jet-pipe in the centre, its lower end reaching near the bottom of A. A pipe passes down from A to near the bottom of B: another pipe is connected with B and passes up to near the top of A. This pipe conducts *air* from B to A. When water is poured into A it runs down the pipe into B; this drives the air up the pipe into the upper part of A, which presses on the surface of the water there and compels it to pass up the jet-pipe and issue out as a fountain, the height of which is equal to the difference of the levels of the water in C and B: the water will, according to the theory, spout to a height above its level in A equal to that distance. The second figure represents the fountain of Hero in another form. An apparatus of this kind is used to drain the Hungarian mines at Schemnitz.





Artificial fountains are also produced by means of the elasticity of heated air, or air condensed by some other means. Two different forms are used for this purpose. The first consists of two close vessels of tin, placed one above the other; the lower one being of considerable size: the upper, furnished with a tube or jet, which reaches to near the bottom of the vessel. On applying the heat of a lamp to the lower vessel, the air within it expands and forcing its way through the open tube is compressed at the top of the vessel, and thus by its pressure forces the water in that vessel through K, L, forming a small jet at K. This apparatus being generally constructed in the form of a temple, produces a very pleasing effect.



FRANKFORT BLACK. Calcined vine ashes, and refuse lees of wine manufactories.

FRANKLINITE is a compound of oxide of iron, with the oxides of manganese and zinc, which is found at Franklin, N. J. It crystallizes in octohedrons, which occasionally by replacements become nearly globular. It commonly occurs in granular masses: it is black, brittle, and has much of the appearance of magnetic iron, but somewhat less metallic, and the streak is reddish brown. It consists of iron 66, oxide of zinc 17, and oxide of manganese 16. Its sp. gr. is 4·87. It is found accompanying the red oxide of zinc, and is often imbedded in limestone, and mixed with garnets and spinelle.

FREEZING. The congelation of a liquid. When cold is applied to any substance, its particles approximate, so that they no longer have the same freedom of motion among themselves: a gas or vapor is condensed into a liquid. Distillation is an ordinary example of this. If the cold be continued still further, or, what is the same thing, if heat continue to be abstracted, the liquid gives out heat, and ultimately becomes a solid; the freezing of water and other liquids are examples. Various degrees of cold are required to bring different liquids into the solid state, and tables of freezing mixtures have been made to accomplish this end artificially. These mixtures are combinations of various salts, which react upon each other, and tend continually to pass from the solid to the liquid state. They hence absorb heat from every thing producing this *intense cold.*

Dr. Ure gives the following as the best proportions for producing artificial cold.

MIXTURES IN PARTS	Thermometer sinks from.	Degree of cold produced.
Phosphate of soda . . 5 Nitrate of ammonia . . 8 Diluted nitric acid . . 4	0° to —84°	84
Phosphate of soda . . 8 Nitrate of ammonia . . 2 Diluted mixed acids . . 4	—84° to —50°	16
Snow . . . . . 8 Diluted nitric acid . . 2	0° to —46°	46
Snow . . . . . 8 Diluted sulphuric acid . 3 Diluted nitric acid . . 8	—10° to —56°	46
Snow . . . . . 1 Diluted sulphuric acid . 1	—20° to —60°	40
Snow . . . . . 8 Muriate of lime . . . 4	+20° to —48°	68
Snow . . . . . 8 Muriate of lime . . . 4	+10° to —54°	64
Snow . . . . . 2 Muriate of lime . . . 8	—15° to —68°	53
Snow . . . . . 1 Cryst. muriate of lime . 2	0° to —66°	66
Snow . . . . . 1 Cryst. muriate of lime . 8	—40° to —73°	83
Snow . . . . . 8 Diluted sulphuric acid . 10	—68° to —91°	23

FRENCH CHALK is a variety of talc, in which the folia are so small that it has a somewhat granular texture and a glimmering lustre.

FRENCH POLISH. This is an alcoholic solution of shellac, some of the softer resinous gums are usually added, but too much of them renders the polish less durable. Highly rectified spirit, not less than 60 over proof, should be used. Rectified wood naptha is sometimes substituted, to which the unpleasant smell is the only objection. 1st. Orange shellac 22 oz., rectified spirits 4 pints, dissolve. 2d. Shellac 3 oz., gum sandarac ¼ oz., rectified spirit 1 pint. 3d. Shellac 4 oz., gum thus. ¼ oz., rectified spirit 1 pint, dissolve and add almond or poppy oil, 2 oz. 4th. Shellac 5 oz., oxalic acid ¼ oz., rectified spirit 1 pint, dissolve and add linseed oil 4 oz. 5th. Shellac 10 oz., seed-lac 6 oz., gum thus. 3 oz., sandarac 6 oz., copal varnish 6 oz., rectified naptha, or dissolve 8 oz. each of seed-lac, gum thus. and sandarac, separately in a pint of naptha; and 1 lb. of shellac in 8 pints of naptha. Then mix 6 oz. of copal varnish, 12 oz. of solution of seed-lac, 6 oz. of solution of frankincense, and 12 of solution sandarac, and 5¼ lbs. solution of shellac. Let the copal varnishes be put into a tincture of shellac, and well shaken, and the other ingredients be added. A correspondent informs us that this polish cannot be excelled. 6th. Copal ¼ oz., gum arabic ¼ oz., shellac 1 oz., pulverize, mix, and sift the powders, and dissolve in a pint of spirit.

French polish is sometimes colored with dragon's blood, turmeric root, &c. The general directions for preparing the polish are to put the gums with the spirit in a tin bottle, and set it on the stove or in water, so as to keep it at a gentle heat, shaking it frequently. The cork should be loosened a little before shaking it, taking care that there is no flame near to kindle the vapor. When the gums are dissolved let it settle for a few hours, and pour off the solution from the dregs. The method of using it is to have a roll of list, over the end of which five or six folds of linen rags are placed. The polish is applied to the linen with a sponge and a little linseed oil is dropped on the centre of it.

FRICTION. In Mechanics, the resistance produced by the rubbing of the surfaces of two solid bodies against each other. If the surfaces of bodies were perfectly smooth and polished, they would slide along one another without suffering any resistance from their contact, and all the simple relations between power and resistance determined by theory in respect of the different machines would hold good without any modification whatever. But this state of perfect polish never exists. The surfaces of all bodies with which we are acquainted, even when most carefully polished, retain a greater or less degree of asperity, which prevents them from sliding over one another without impediment; and in many cases the resistance thus created amounts to a large proportion of the whole resistance to be overcome. In order, therefore, to ascertain the real value of the effect of powers applied to machinery, it is necessary to determine the amount of the friction, and to add this new resistance to that which is given by the theory of mechanics.

The determination of the laws of friction, and its amount with respect to particular substances, have occupied the attention of many experimental philosophers and mathematicians, as Amontons, Euler, Desaguliers, Vince, &c.; but the first complete set of experiments on the the subject was made by Coulomb about the year 1780. His results, though they have been partly modified by subsequent experiments, throw much light upon the subject, and are of great value to the practical engineer.

There are two modes by which the nature and operation of friction may be ascertained. The first is very simple, and consists in merely placing a heavy body on a horizontal plane, and elevating the end of the plane till the body begins to slide. When this motion commences, it is evident that the force of gravity just begins to exceed the resistance occasioned by the friction; and as the gravity is known from the weight of the body, and the inclination of the plane, we have thus the means of comparing the friction with a given force.

But this method is liable to some uncertainty. Most bodies, after having been in contact for some time, require a greater force to originate than to keep up progressive motion; but it is obvious that the inclination of the plane of descent marks only the initial obstruction. Coulomb accordingly adopted a different mode of proceeding. His general method was to draw a sort of loaded sledge along a horizontal bench, by means of weights placed in a dish attached to the sledge by a cord passing over a pulley. The sledge was mounted on sliders of the substance on which the experiments were to be made; and the corresponding slips of the same or a different substance placed upon the sliders on the bench. This apparatus has been called a *tribometer*. The following are some of the results which were obtained.

Assuming the pressure as equal to 100 parts, the friction of oak against fir was 66 in the direction of the fibres, but amounted only to 16 when moved with the velocity of a foot each second; the friction of oak against oak in the direction of the fibres was 48, and across them only 27, the effect being still reduced by motion to 10; the friction of fir against fir in the direction of the fibres was 56, which sunk to seventeen during motion; the friction of elm against elm in the direction of the fibres was 46, and reduced by motion to 10. On the other hand, the friction of copper upon oak, lengthwise, was 8 at the commencement of the motion, but increased to 18 when the velocity was a foot in a second; the friction of iron upon oak with the initial velocity was 11, and was increased by the motion to 18. But the mutual friction of metals appeared in general to be scarcely, if at all, affected by motion. In these experiments no unguents were used.

Where metals rub against wood, it is necessary that the two bodies continue longer in contact, in order that the friction may acquire its maximum. In the case of iron against wood at least 4 or 5 hours must elapse before the momentary increase of friction disappears; whereas in the case of wood against wood a single minute was sufficient. But the resistance appears to increase by contact, though less sensibly, even for several days. The application of grease to the surfaces of wood produces a similar effect, and the resistance does not attain its maximum till after a very considerable time. At the end of 5 or six days the resistance is perhaps 14 times greater than it was at the first instant, if the surface of contact is considerable in respect of the pressure; but when the surface is small, the friction reaches its maximum much more quickly.

An important part of the investigation was to ascertain whether the friction is increased by the velocity of the rubbing bodies. With respect to the bodies of the same kind descending on inclined planes, Coulomb found that the time required for passing over the first half was a little more than double that required for passing over the second. But a body put in motion by a constant accelerating force employs for passing over one space, and over two equal consecutive spaces, times that are to each other in the ratio of $\sqrt{1} : \sqrt{2} = 100 : 142$; that is to say, if 100 units of time are consumed in passing over the first space, 142 will be consumed in passing over the first and second together, and consequently 42 in passing over the second. Now this agrees as nearly as possible with the result of the experiments; consequently we infer that a load drawn along a smooth plane by a constant accelerating force (that of a descending weight for example) is uniformly accelerated. But this requires that the friction, at every instant, destroys only a proportional quantity of the force added by the constant action of gravity. The conclusion therefore is, that for moderate velocities at least, *the resistance due to friction is a constant quantity*, and very nearly the same for every degree of velocity.

Another point of great importance was to ascertain the relation the friction bears to the pressure; for example, in what ratio the friction has increased by doubling or trebling the load. Coulomb found that when wood has been allowed to rest on wood for some time, without the intervention of any unguent, the resistance occasioned by the friction is proportional to the pressure. The resistance for a short time increases rapidly by the contact, but attains its maximum in a few minutes. The friction of wood sliding on wood with any velocity is still proportional to the pressure; but the resistance is much less in amount than that which is required to detach the surfaces after some minutes of contact. In the case of oak, for instance, the force required to detach the surfaces after being some minutes in repose is to that which is necessary to overcome friction alone after motion has commenced in the ratio of 100 to 23. The friction of metals on metals is also proportional to the pressure; but the intensity is the same, whether the surfaces have been any length of time in contact, at rest, or are gliding along with a uniform velocity.

The friction of heterogeneous substances, as woods and the metals, is entirely different from the above. In the case of wood against wood dry, or of metal against metal, the friction of the rubbing bodies is very little influenced by the velocity; but in the present case the friction increases very sensibly with an augmented velocity. Coulomb inferred that the friction increased as the natural numbers, when the velocities are increased as the squares of those numbers. In all cases of a hard body rubbing against a very soft substance, the friction increases remarkably with the velocity.

Since the friction is in general proportional to the pressure, it follows that it will not be altered by increasing or diminishing the extent of the rubbing surfaces. Nevertheless, this consequence fails in the extreme cases. The friction is sensibly diminished when the surfaces in action are reduced to the smallest dimensions. Thus, while the friction of a ruler of brass against a similar one of iron is expressed by 26, it was found to be only 17 after the sledge had been mounted on 4 round-headed brass nails.

Other causes of friction are the roughnesses, spiculæ, and angles of surfaces removeable by filling them with oil-tallow, &c., and by diminishing the extent of surface in contact. Olive-oil reduces the friction of woods one-half.

In all cases, the rubbing of large surfaces against each other should be avoided; and hence the use of little wheels to turn with the axis of shafts called friction-wheels, by which the contact and rubbing of large breadths is avoided. Different substances, too, should work against one another, the ultimate atoms of the bodies tending to combine by their similarity of forms.

In the screw and the wedge, the friction is equal to the power. The sheaves of pullies should not press against the blocks.

It has been carefully determined at Baltimore, that one quart of oil is sufficient for 2000 miles run of a steam-carriage weighing 3 tons. In the Winan's waggon, the friction-wheels dip into the oil; but being in a cast-iron case, none is lost, while the renewal of oil is better than the same in long work. Purified vegetable oils answer best.

Black-lead is found to destroy friction with the best effect.

Ferguson found that the quantity of friction was always proportional to the weight of the rubbing body, and not to the quantity of surface; and that it increased with an increase of velocity, but was not proportional to the augmentation of celerity. He found also, that the friction of smooth soft wood, moving upon smooth soft wood, was equal to one-third of the weight; of rough wood upon rough wood, one half of the weight; of soft wood upon hard, or hard upon soft, one-fifth of the weight; of polished steel upon polished steel or pewter, one quarter of the weight; of polished steel upon copper, one-fifth; and of polished steel upon brass, one sixth of the weight. Coulomb brought to light many new and striking phenomena, and confirmed others, which were previously but partially established.

The obstruction which a cylinder meets with in rolling along a smooth plane is quite distinct in its character, and far inferior in its amount, to that which is produced by the friction of the same cylinder drawn lengthwise along a plane. For example, in the case of wood *rolling* on wood, the resistance is to the pressure, if the cylinder be small, as 16 or 18 to 1000; and if the cylinder be large, this may be reduced to 6 to 1000. The friction from sliding, in the same cases, would be to the pressure as 2 to 10, or 3 to 10, according to the nature of the wood. Hence, by causing one body to roll on another, the resistance is diminished from 12 to 20 times. It is therefore a principle in the composition of machines, that attrition should be avoided as much as possible, and rolling motions substituted whenever circumstances admit.

On this principle depends the advantages resulting from the application of *friction wheels* and *friction rollers.* The extremity of an axle, instead of resting in a cylindrical socket, is made to rest on the circumference of two wheels, to the axles of which the friction is transferred, and consequently diminished in the ratio of the radius of the wheel to the radius of the axle. This ingenious contrivance appears to have first been applied by Henry Sully, in the year 1716.

Soapstone has been used for diminishing friction with great profit and success. It is first thoroughly pulverized, and then mixed with oil, tallow, lard, or tar. It is used in all kinds of machinery where it is necessary to apply any unctuous substance to diminish friction, and it is an excellent substitute for the usual composition applied to carriage vehicles.

Perkins has avoided the necessity of employing oil, grease, or any other lubricator to the piston of the steam engine by forming his piston of bell-metal, composed of the following materials:—copper, 20 parts; tin, 5 parts; zinc, 1 part. This, as well as his cast-iron cylinder, is cast under the pressure of a considerable head of metal; by which means the density and closeness of grain of both of them is very greatly increased, and indeed, the cast-iron has as close a grain as wrought-iron itself. These two metals he finds to act *so as to polish each other in use.* He also uses the same dense cast-iron to form his steam-engine crank-axes, and the spindles of axes of his grindstones, &c., with; and he runs the cylindrical necks of them upon bearings formed of his bell-metal, placed underneath them, and made with hollow cylindrical cavities, across their upper faces, not exceeding the sixth part of a circle in extent; and yet, upon these very small bearings, his necks run, with a very trifling portion indeed of grease, as a lubricator. In this manner, the cylindrical necks of the axis of a large grindstone, employed in grinding large articles, run; and yet, on throwing off the band from the rigger, or band-wheel, the stone will make fifty revolutions at least before it stops.

FUEL. Any combustible substance which is used for the production of heat, constitutes a species of fuel; and in this extended sense of the term, alcohol, wax, tallow, coal gas, oil, and other inflammable bodies which are occasionally used, especially in the chemical laboratory, as sources of heat as well as light, might be included under it. But the term *fuel* is more properly limited to coal, coke, charcoal, wood, and a few other substances, which are our common *sources of heat,* and as such are burned in grates, stoves, fireplaces, and furnaces of different descriptions.

In this country, coal, in the neighborhood of cities, is the fuel commonly employed; but where wood is abundant, or where its value is little more than that of felling it, it is used either in its original state or in the form of charcoal. But whatever substance is used, the ultimate elements of fuel are carbon and hydrogen; and the heat which is evolved by their combustion is derived from their combination at high temperatures with the oxygen of the air: the results or products of this combustion are carbonic acid and water, these escaping into the atmosphere by the flue or chimney generally attached to furnaces and fireplaces.

It is essential to good and profitable fuel that it should be free from moisture; for unless it be dry, much of the heat which it generates is consumed in converting its moisture into vapor: hence the superior value of old, dense, and dry wood, to that which is porous and damp; hence also the greater quantity of heat evolved during the combustion of charcoal as compared with that of wood, for even the driest wood always retains a certain quantity of water; hence also coke gives out more heat than pit coal, partly because it is absolutely dry, and partly because during the combustion or heating of coal, tar, oil, water, and gas are evolved, all of which carry off a certain proportion of the heat in a latent form. A pound of dry wood will, for instance, heat 35 pounds water from 32° to 212°, and a pound of the same wood in a moist or fresh state will not heat more than 25 pounds from the same to the same temperature; the value, therefore, of different woods for fuel is nearly inversely as their moisture, and this may be roughly ascertained by finding how much a given weight of their shavings loses by drying them at 212°.

Charcoal is itself very hygrometric, and when exposed to air increases in weight to the amount of 10 or 12 per cent. in consequence of the absorption of humidity: a pound of dry charcoal is capable of raising, when properly burned, 73 pounds of water from the freezing to the boiling point.

The different kinds of pit coal give out variable quantities of heat during their combustion; upon an average, one pound of coal should raise 60 pounds of water from the freezing to its boiling point. The heating power of coke as compared with coal is nearly in the ration of 75 to 69: a pound of good coke will heat from 64 to 66 pounds of water from 32° to 212°; its power, therefore, is about nine-tenths that of wood charcoal.

The value of turf and peat as fuel is liable to much variation, and depends partly upon their density, and partly upon their freedom from earthy impurities. A pound of turf will heat about 26 pounds of water from 32° to 212°, and a pound of dense peat about 30 pounds: by compressing and drying peat its value as a fuel is greatly increased.

The following table, by Dr. Ure, shows the quantity of water raised from 32° to 212° by one pound weight of the different combustibles enumerated in the first column; it also shows the number of pounds of boiling water, which the same weight of fuel will evaporate, and the quantity of atmospheric air absolutely consumed during combustion. The quantity of air, however, as given in the last column, is much less than would be necessary in practice, where much of the air passes the fuel without coming into contact with it so as have its oxygen consumed. The heating power also, as represented by this table, can seldom be *practically* attained.

Combustible.	Pounds of Water which a Pound can raise from 32° to 212°.	Pounds of Boiling Water evaporated by one Pound.	Weight of Atmospheric Air at 32° required to burn one Pound.
Dry wood . . .	35·00	6·36	5·96
Common wood .	26·00	4·72	4·47
Charcoal . . .	73·00	13·27	11·46
Pit coal. . . .	60·00	10·90	9·26
Coke	65·00	11·81	11·16
Turf.	30·00	5·45	4·60
Coal gas . . .	76·00	13·81	14·58
Oil, wax, or tallow	78·00	14·18	15·00
Alcohol . . .	52·00	9·56	11·60

FUEL, ARTIFICIAL. Coal, in its natural state, consists principally of bitumen, carbon, and some earthy matters. All fuel contain substances possessing bituminous and carbonaceous properties. Various compounds have been brought forward from time to time, some of them patented, to produce artificial fuel. All those compounds have been combinations of substances of a carbonaceous and bituminous nature, capable of generating inflammable gas and sustaining combustion. Among the first compounds was refuse coal dust, with pitch, which was capable of producing an intense heat. A patent was taken out in London, in 1800, by a Mr. P. Davy, for an artificial fuel, to burn without smoke or sulphurous smell. It was composed of sea coal dust mixed with charcoal, tanners' bark, and saw-dust. The materials were mixed together wet, placed in a kiln and slightly cooked, care being taken not to use too high a temperature. Another artificial fuel was to place upon a shelf, above the fire, a quantity of chalk, or lime, which becoming heated from the combustion of the coal below, concentrated the heat for a long time. Another plan was to bake bituminous and anthracite coal together, to produce a very lasting coke. The proportions were one-third of the bituminous. Another plan was that of a Mr. T. Sunderland, who took out a patent for a compound of gas-tar, clay, saw-dust, tanners' bark, and refuse dyewood; all were mixed together, formed into cakes, and dried by any artificial heat. Another compound, and patented too, was saw-dust, spent bark, coke, cinder ashes, and clay, reduced to powder, mixed, cut and dried into cakes, and then dipped into coal tar, or grease, and afterwards dried. Another compound was peat, clay, nitre, alum, linseed and resin, all ground in a mill and pressed into moulds, like bricks, and afterwards dried in the sun. Another, and an ingenious plan, to harden peat, or swamp earth, was to mix it with powdered coal, or powdered brimstone, to break up the fibres and deprive the peat or swamp earth of its water, afterwards pressing it and making it into hard blocks. Another compound, by a Mr. Stirling, patented in England, was to mix pulverized coal with tar and clay. All were intimately mixed together, moulded into blocks and dried, and then they were excellent in shape for stowage. The great object of the producers of artificial fuel has been to make it in such a shape that it would be easily stowed away for sea voyages, but the expense always exceeded the benefits. We might enumerate a great number of compounds of the above nature, varying but little from one another, but which constitute the subjects of no less than twenty-one patents, recorded in the London Repertory of Arts, and in the List of American Patents. Very favorable accounts are given of using the gas-tar along with spent-tan bark, in the gas-works, to heat the retorts. A patent was taken out in Washington, last year, for the compressing of coal dust into fuel. Another kind is made at Newton's Corners, near Albany, N. Y., by grinding swamp muck in a pug mill, then submitting it to a very severe pressure, and afterwards drying it. It is represented to burn well.

We know of no kind of fuel, taking it for all in all, that can equal the anthracite. It is compact and cleanly, good qualities certainly; but it has another, viz., great and enduring calorific qualities. Bituminous coal is good fuel, but very uncleanly, for domestic use especially. One thing can make its use more agreeable, namely, to burn the smoke. This can be done by injecting fine jets of air on the top of the coals.

FULLER'S EARTH is a soft, friable, coarse or fine grained mass of lithomarge clay. Its color is greenish, or yellowish gray; it is dull, but assumes a fatty lustre upon pressure with the fingers, feels unctuous, does not adhere to the tongue, and has a specific gravity varying from 1·82 to 2·19. It falls down readily in water, into a fine powder, with extrication of air bubbles, and forms a non-plastic paste. It melts at a high heat into a brown slag. Its constituents are 53·0 silica; 10·0 alumina; 9·75 red oxide of iron; 1·25 magnesia; 0·5 lime; 24 water, with a trace of potash. Its cleansing action upon woollen stuffs depends upon its power of absorbing greasy matters. It should be neither tenacious nor sandy; for in the first case it would not diffuse itself well through water, and in the second it would abrade the cloth too much. The finely divided silica is one of its useful ingredients.

After baking it is thrown into cold water, where it falls into powder, and the separation of the coarse from the fine is effectually accomplished, by a simple method used in the dry color manufactories, called washing over. It is done in the following manner: Three or four tubs are connected on a line by spouts from their tops; in the first the earth is beat and stirred, and the water, which is continually running from the first to the last through intermediate ones, carries with it and deposites the fine, whilst the coarse settles in the first. The advantages to be derived from this operation are, that the two kinds will be much fitter for their respective purposes of cleansing coarse or fine cloth; for without baking the earth they would be unfit, as before noticed, to incorporate so minutely with the water in its native state; it would neither so readily fall down, nor so easily be divided into different qualities, without the process of washing over. When fuel is scarce for baking the earth, it is broken into pieces of the same size, as mentioned above, and then exposed to the heat of the sun.

The benefit of fuller's earth is mainly due to the alumina, which, by rubbing on the cloth unites with the grease, forming a soap which may either be washed, or may serve as a mordant to fix the colors better on the stuffs.

FULLING. The art of cleansing, scouring, and pressing stuffs, cloths, stockings, &c., to render them stronger, firmer, and closer; it is also called *milling*, because these cloths, &c., are in fact scoured by a water mill.

FULMINATES. Compounds of the fulminic acid with various bases, all more or less possessed of the property of exploding or detonating by heat or friction. The fulminates of silver and mercury (or fulminating silver and mercury) are objects of manufacturing interest; the former being used in detonating *bonbons*, and the latter more largely and importantly as a priming for the percussion caps of gun locks.

FULMINATING POWDER. A compound of three parts of nitre, two of purified pearlash, and one of flowers of sulphur, carefully mixed and dried before the fire: about 20 grains of this powder heated upon an iron plate over a slow fire becomes brown and pasty; a blue flame then appears upon it, and immediately after the whole explodes with a stunning report.

FUNNEL. In architecture, the upper part of a chimney. In common life, it is a trumpet-mouthed utensil, with a pipe fixed to the apex for the purpose of conveying liquors into a vessel without spilling them.

FUMIGATION, is the employment of fumes or vapors to purify articles of apparel, and goods or apartments supposed to be imbued with some infectious or contagious poison or fumes. The vapors of vinegar, the fumes of burning sulphur, explosion of gunpowder, have been long prescribed and practised, but they have in all probability little or no efficacy. The diffusion of such powerful agents as chlorine gas, muriatic acid gas, or nitric acid vapor, should alone be trusted to for the destruction of morbific effluvia.

FUNICULAR MACHINE. In mechanics, if a body fixed to two or more ropes is sustained by powers which act by means of those ropes, the assemblage is called the *funicular machine*, or *rope machine*. If a rope is stretched horizontally between two points, its own weight alone will prevent it from becoming perfectly straight, whatever force be employed in stretching it; and a very small force applied at its middle point, at right angles to its direction, will be sufficient to overcome a very great resistance at the points to which its extremities are attached. In this manner a very small force may be made to raise a very great weight to a minute height. This method of applying force is familiar to seamen, who frequently have recourse to it in bracing their sails.

FUR. The coated skins of wild animals, especially of those of high northern latitudes; such as the wolf, bear, beaver, &c. The hair of fur is cleansed, and the skin is generally slightly tanned or tawed. The most valuable furs, such as ermine and sable, come chiefly from Russia. When unprepared, or merely dried, the fur skins go under the name of *peltry*.

FURNACES bear various names, according to their purpose. The object of all is to procure great heat, directly applicable to the purpose.

Iron furnaces consist of a cone 20 or 30 feet deep, to receive the ore, the flux, and the coke or fuel, in layers, with an ash grate beneath, and blasting bellows to increase the supply of oxygen. They are many weeks in preparation, so as to acquire a high degree of heat, and then they are never suffered to cool, but constantly supplied with ore, flux, and fuel.

A *gas furnace* is so built that the fire and flame surround the retorts full of coal, and keep them at a white heat.

A *chemical furnace* is more various in its uses, and should be built with a table-top, and horizontal flue covered with plate iron, over which should be sand baths, and other receptacles, with hoods and covers.

The *air-furnace*, for melting, has an ashes hole, and a lateral hole near the bottom of the grate. The fire-place is inclosed, and fuel put in at the top, so as to surround the covered crucibles or cucubets placed in the fire. The exit of smoke, &c., is at the side, in a horizontal flue.

A *reverberatory furnace* is one closed at the top, or with a reverberating dome with a fire beneath, and a perpendicular flue through the dome. At the side is an orifice for the neck of any retort placed in the body.

There are various patent and special varieties of furnaces, but the same general forms pervade them. Charcoal, or coke, or ashes, produce the highest heat, but coals are used in glass-houses, distilleries, and breweries.

Accum's Lamp Furnace is very convenient and powerful for operations in the small way. In the burning part it is Argand's lamp, but, on the upright standard, three or four arms slide with rings at their ends, to raise higher and lower, and fix with nuts and screws, adapted to receive retorts, alembics, flasks, &c., for distillations, digestions, &c. In some, a second cylinder and second flame is made, by which the heat is trebled, and most processes performed in a small way, without a furnace.

The furnace of the *Royal Institution* is of brick-work, 52 inches by 30. The iron plate and sand-baths, 57 by 42. It is 34 inches high.

A very powerful furnace, equal to any purpose, has been made at the Royal Institution, by cutting the bottom off a blue pot, and fixing it tight in a larger one, 18 by 13 inches; then, through a single hole in the bottom of the outer pot, blowing with a pair of double bellows. It melts pure iron in a quarter of an hour, renders platinum soft, and fuses rhodium. The fuel is coke, and it disappears, leaving scarcely slag; proving the superiority of the blast furnace over all others.

Faraday states, that a pint of water may be boiled in a cartridge-paper vessel, placed over a chemical lamp.

Mr. Nott has taken out a patent for a mode of giving to furnaces a circular or semicircular form, that the fresh coals, when the fire receives a supply of them, may be, by turning the furnaces on pivots, by which it is supported, brought into a position with reference to the coals already ignited, that the gaseous products of the fresh coals shall pass through the ignited portion, that the combustible part may be consumed; and thus effect a saving of fuel, and the prevention of much of the nuisance arising from the escape of unconsumed smoke. This rotating, or rather vibrating furnace, is of course to be provided with an iron casing, to surround the sides of the furnace not intended to be exposed.

By Witty's improved furnace, fresh coal is first carbonized, that is, the gas is separated from it and inflamed, leaving only coke, which, being slowly pushed forward, supplies the coke fire; and the combustion or burning of the coke produces heat enough to carbonize the coal, and air enough to inflame the gas; consequently, coal, instead of being burned in its usual crude state, is subjected to two distinct processes, viz. carbonization, and then combustion; for, by this contrivance, he burns the gas and the coke together.

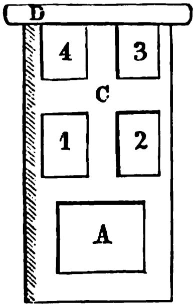
The vent of a furnace has given rise to much difference of opinion as to the size it ought to have. Some make it large, to allow a freer passage for the burnt air into the chimney; others again, small, that the heat may not be dissipated and carried up into the chimney in waste. It is generally a single opening, but, in porcelain furnaces, the manufacturers use a number of small openings, instead of a single vent, with the view of assisting in the equal distribution of the heat throughout all parts of the chamber, and this practice should be adopted whenever this equal distribution is requisite. These artists are also careful that the sum of the areas of these holes should be exactly equal to that of the throats by which the flame and heated air enters into the chamber. It seems, therefore, advisable, in all cases, to make the vent or vents equal in area to that of the free space left between the bars of the grate. Mr. Losh proposed to remove the vent to the front of the furnace, immediately over the feeding or stoking-door, and to conduct the burned air, through channels made in the masonry, into the flue of the chimney. A great advantage attends this construction, that, when either of the entrances into the fire-room are opened, the indraught of air, instead of rushing over the surface of the burning fuel, and striking against the vessels and materials, instantly passes up the vent, and does not enter at all into the interior of the furnace, whence this is much less cooler than in the furnaces of the usual construction.

The chimney, or flue, is one of the most important parts of a furnace; and yet, in general, the least attended unto; being usually made much too large in its horizontal area. By making it thus large, the draught through it is much diminished, and the soot collects and becomes troublesome. For, when the sides of the flue contain a larger surface than can be duly heated, the necessary rarefaction of the air passing through it is destroyed. On this principle, alone, the draught of chimneys depends; and the cavity being too large proportionably to the current of air, the force of it is so diminished that the soot, instead of being blown out, gathers and rests on the sides till it obstructs the passage, and choking up the draught deadens the fire, especially at the first lighting of it, by which means the progress of the operation is sometimes greatly retarded. Instead, therefore, of the large proportion now made use of, if the chimney be intended for the use of one furnace only, an area equal to that of the free space between the bars of the grate is fully sufficient; and this may be increased in proportion, where it is designed for a greater number.

The calculations of Tredgold show that each side of a chimney having a square basis, or the narrowest side, if the basis be rectangular, should be, at the least, one foot in breadth for every 10 feet in height; and the area of the flue ought not to exceed one-third of the area of the chimney.

The wall of chimneys is usually single, but when the air which passes up the flue is very hot, it has been found preferable to have the wall double, with an empty space left between the two, which are tied together from space to space, by bricks passing from one to the other.

FURNACE. (Russian.) A kind of furnace adapted for burning wood, and used much in the villages and rural districts in New England. It consumes less wood than a stove, and requires but little care, preserving an agreeable and equal temperature in the room, as it presents a greater amount of heated surface than a stove, and does not require to be so intensely heated up.



The annexed cut represents this furnace in a transverse section. A is the fire place, to which an iron door is fixed. C is the brick-work; D a soapstone cap; 1 2 3 4 are flues in connexion with each other, and 1 being in connexion with A; to 4, a funnel connecting the flue with the chimney is fixed, which has a damper attached. The furnace should stand out a few inches from the chimney, so as to save the heat from all sides.

The fire place is filled with wood, and the dampers opened till the wood gets well on fire. The dampers are then closed perfectly tight, though not so suddenly as to make it smoke. It will want no more attention till the wood is nearly gone, when it can be replenished and immediately shut up if there are plenty of coals. It never need be opened more than three times a day in coldest weather, morning, noon, and night, and in more moderate weather not more than once or twice. The draught is generally good.

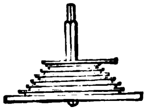
A common form is about three feet in length, sixteen inches wide, two and a half feet high—though the size should depend upon the size of the room. They may be built upon the floor by having a sufficient thickness of brick between the floor and fire. The cost of one made all of brick, is not over four dollars, (pressed brick). A new furnace must be dry before it is used.

FURNACE (SALTER'S). Mr. Salter, of New Jersey, has taken out a patent for his improved furnace, which is adapted to ores, yielding 40 per cent. and upwards of iron. It consists of a triple chambered furnace, one above the other--the ore being pulverized and mixed with hard coal, and ground fine, is placed in the upper chamber—where the gases and impurities, such as sulphur, &c., are carried off at low temperature. From thence it is drawn through openings in the bottom, into the second or middle chamber, where the fluxing materials are added—thence it is drawn down openings to the lower or puddling chamber—the whole process occupying less than an hour and a half.

Five men are required each turn to work the furnace, and the yield is about 400 lbs. per hour and a half. Two and a half tons coal are consumed in 24 hours. The cost of the iron will vary according to the facilities for getting the ore and coal, the cost of labor, &c. Former experiments have proved, as far as they have been made, that anthracite coal does better as the deoxidizing material than bituminous coal, and quite as well as charcoal, but the bituminous coal is quite as good (though no better) as either for fuel to heat the ores.

It is stated that iron of the first quality can be made by it at Newark, and sold in New-York at $25 per ton.

FUSEE. In watch-work, that part of the machinery about which the chain is wound, and which is immediately acted upon by the mainspring. The use of the fusee is to equalize the action of the spring. In proportion as the spring becomes unwound, its effort continually relaxes; so that if the first wheel were attached to the barrel, as is often the case in common watches, the inequality of the impelling power would produce a corresponding inequality in the rate of going. In order to correct this, one end of the chain is attached to and wound round the barrel in which the main-spring is contained; while the other end is coiled about the fusee, which has a conical shape, and is fixed on the axis of the first wheel. The principle generally adopted for determining the figure of the fusee is, that its radius, at any point to which the chain is a tangent, should be inversely as the tension of the chain in that position. Within certain limits this is true; and if we assume with Hooke, that the force of a spring is proportional to the distance to which it is drawn from the position of rest, and also lay aside all consideration of the length of the chain wrapped about the fusee, it would be easy to show that the fusee should be the solid generated by the revolution of the equilateral hyperbola about its asymptote. This conclusion is, however, by no means correct; but though the subject has been treated by several eminent mathematicians, very little practical advantage has been derived from the theoretical investigations. In fact, a moderate approximation to the



true figure (whatever that may be) is all that can be attained in practice, and all that is necessary.

FUSIBILITY. That property by which solids assume the fluid state.

Some chemists have asserted that fusion is simply a solution in caloric; but this opinion includes too many yet undecided questions, to be hastily adopted.

Fusibility of Metals, as given by M. Thenard.

1. Fusible below a red heat.

	Centigr.
Mercury	—39°
Potassium	+58
Sodium	90
Tin	210
Bismuth	256
Lead	260
Tellurium	Less fusible than lead.
Arsenic	Undetermined.
Zinc	370°
Antimony	A little below a red heat.
Cadmium	

2. Infusible below a red heat.

	Pyrometer of Wedgewood.
Silver	20
Copper	27
Gold	33
Cobalt	A little less difficult to melt than iron.
Iron	130 158
Manganese	160
Nickel	As manganese.
Palladium	Nearly infusible; and to be obtained at a forge heat only in small buttons.
Molybdenum	
Uranium	
Tungsten	
Chromium	
Titanium	Infusible at the forge furnace. Fusible at the oxy-hydrogen blowpipe.
Cerium	
Osmium	
Iridium	
Rhodiun	
Platinun.	
Columbium	

FUSIBLE METAL. *See* ALLOY.

FUSTET. The wood of the *rhus cotinus*, a fugitive yellow dye.

FUSTIAN is a species of coarse thick tweeled cotton, and is generally dyed of olive, leaden, or other dark color. Besides the common fustian, which is known by the name of pillow (probably pilaw), the cotton stuffs called corduroy, veverett, velveteen, thicksett, used for men's wearing apparel, belong to the same fabric. The commonest kind is merely a tweed of four, or sometimes five leaves, of a very close stout texture, and very narrow, seldom exceeding 17 or 18 inches in breadth. It is cut from the loom in half pieces, or ends, as they are usually termed, about 35 yards long, and after undergoing the subsequent operations of dyeing, dressing, and folding, is ready for the market.

FUSTIC. The *old* fustic of the English dyer, as the article fustet is their *yellow* fustic. It is the wood of the Morus tinctoria. It is light, not hard, and pale yellow with orange veins; it contains two coloring matters, one resinous, and another soluble in water. The latter resembles weld, but it has more of an orange cast, and is not so lively.

Its decoctions in water are brightened by the addition of a little glue, and more by curdled milk. This wood is rich in color, and imparts permanent dyes to woollen stuffs, when aided by proper mordants. It unites well with the blue of the indigo vat, and Saxon blue, in producing green of various shades. Alum, tartar, and solution of tin, render its color more vivid; sea salt and sulphate of iron deepen its hue. From five to six parts of old fustic are sufficient to give a lemon color to sixteen parts of cloth. The color of weld is however purer and less inclined to orange; but that of fustic is less affected by acids than any other yellow dye. This wood is often employed with sulphate of iron in producing olive and brownish tints, which agree well with its dull yellow. For the same reason it is much used for dark greens.

GADOLINITE or YTTERITE, is a mineral black, brownish, or yellow color, granular or compact, vitreous and conchoidal in fracture; of spec. grav. 4·23. It readily scratches glass, and melts before the blow-pipe into an opaque glass, and sometimes with intumescence. It affords, with acids, a solution which gives with soda a precipitate partly soluble in carbonate of ammonia. It contains nearly 50 per cent. of the earth yttria. Its remaining constituents are silica, 25·8, oxide of cerium 17·92, oxide of iron 11·43. This mineral is rare, found at Fahlun and Ytterly in Sweden, and also in the south of Ireland. Its peculiar constituent was discovered by Dr. Gadoline, hence the name.

GAGE or GAUGE. In architecture, the length of a slate or tile below the lap; also the measure to which any substance is confined. Plasterers use the word to signify the greater or less quantity of plaster of Paris used with the common plaster to accelerate its setting.

GAGE. In physics, an instrument or apparatus for measuring the state of a phenomenon. *Gage of the air pump* is merely a barometer communicating with the inside of the receiver, which marks, in the usual manner, the pressure of the air within the receiver by the height of the equiponderant column of mercury, and consequently shows the degree to which the air is rarefied. A short barometer may be employed for this purpose; but in this case it will not be affected till the rarefaction of the air has been carried so far as to correspond with the length of the tube. An instrument for the same purpose, but on a different principle, was invented by Smeaton, and from its form called a *pear-gage*. It is a vessel suspended in the receiver, and exhausted to the same degree; but when the rarefaction is carried as far as intended, the open orifice of the gage is let down into a vessel containing mercury, which, on the readmission of the air, is forced up into the pear, and the degree of rarefaction is judged of by the quantity of mercury introduced. The idea is ingenious; but the indications given by this instrument are not correct. For *wind-gage*, see ANEMOMETER; *water-gage*, see HYDROMETER.

GALENA. Sulphuret of lead, found massive and in cubic crystals. Color is blue gray, like lead, but brighter; lustre, metallic; breaking into cubic fragments, soft but brittle. Spec. grav. 7·22 to 7·58; it effervesces with nitric and hydrochloric acids, and contains from 45 to 83 per cent. of lead, and from 56 to 16 of sulphur. It also contains some silver and occasionally antimony, zinc, iron and bismuth. Before the blow-pipe it decrepitates, and is decomposed and melted on the charcoal, yielding a button of metallic lead. Sometimes as much as 100 oz. of silver will be found in a ton of ore; it is then worked as a silver ore, and called argentiferous galena. The varieties which contain most silver are not the most lustrous, being sometimes black-gray; occasionally galena is mixed with silex and lime, and only yields 50 per cent. of lead. Sulphuret of lead occurs in primitive and metamorphic beds, but more frequently in the upper secondary, especially in the compact blue limestone alternating with fossiliferous beds; occasionally it is found in beds of coal, and bitumen is rarely found in its veins. Galena is abundant in Great Britain, and widely dispersed over this country. The mines of Missouri are very rich and extensive, and still more so those extending through Illinois, Iowa, and Wisconsin, of which Galena is the centre. This lead region embraces about three thousand square miles in the S. E. of Iowa, extending across the Mississippi into Wisconsin and Illinois. Most of the metallic lead is obtained from galena, and contains a little silver. (*See* LEAD.)

GALL OF ANIMALS, or OX-GALL, *purification of*. Painters in water colors, scourers of cloth, and many others, employ ox-gall or bile; but when it is not purified, it is apt to do harm from the greenness of its own tint. It becomes therefore an important object to clarify it, and to make it limpid and transparent like water. The following process has been given for that purpose. Take the gall of newly killed oxen, and after allowing it to settle for 12 or 15 hours in a basin, pour the supernatant liquor off the sediment into an evaporating dish of stone ware, and expose it to a boiling heat in a water bath, till it is somewhat thick. Then spread it upon a dish, and place it before a fire till it becomes nearly dry. In this state it may be kept for years in jelly pots covered with paper, without undergoing any alteration. When it is to be used, a piece the size of a pea is to be dissolved in a tablespoonful of water.

Another and probably a better mode of purifying ox-gall is the following. To a pint of the gall boiled and skimmed, add an ounce of fine alum in powder, and leave the mixture on the fire till the alum be dissolved. When cool, pour into a bottle, which is to be loosely corked. Now take a like quantity of gall, also boiled and skimmed, add an ounce of common salt to it, and dissolve with heat; put it when cold into a bottle, which is likewise to be loosely corked. Either of these preparations may be kept for several years without their emitting a bad smell. After remaining three months, at a moderate temperature, they deposit a thick sediment and become clearer, and fit for ordinary uses, but not for artists in water colors and miniatures, on account of their yellowish-green color. To obviate this inconvenience, each of the above liquors is to be decanted apart, after they have become perfectly settled, and the clear portion of both mixed together in equal parts. The yellow coloring matter still retained by the mixture coagulates immediately and precipitates, leaving the ox-gall perfectly purified and colorless. If wished to be still finer, it may be passed through filtering paper; but it becomes clearer with age, and never acquires a disagreeable smell, nor loses any of its good qualities.

Clarified ox-gall combines readily with

coloring matters or pigments, and gives them solidity either by being mixed with or passed over them upon paper. It increases the brilliancy and the durability of ultramarine, carmine, green, and in general of all delicate colors, whilst it contributes to make them spread more evenly upon the paper, ivory, &c. When mixed with gum-arabic, it thickens the colors without communicating to them a disagreeable glistering appearance; it prevents the gum from cracking, and fixes the colors so well that others may be applied over them without degradation. Along with lamp-black and gum, it forms a good imitation of China ink. When a coat of ox-gall is put upon drawings made with black lead or crayons, the lines can be no longer effaced, but may be painted over safely with a variety of colors previously mixed up with the same ox-gall.

Miniature painters find a great advantage in employing it; by passing it over ivory it removes completely the unctuous matter from its surface; and when ground with the colors, it makes them spread with the greatest ease, and renders them fast.

It serves also for transparencies. It is first passed over the varnished or oiled paper, and is allowed to dry. The colors mixed with the gall are then applied, and cannot afterwards be removed by any means.

It is adapted finally for taking out spots of grease or oil.

GALL OF GLASS. The salts and other impurities which float upon the fused materials for the manufacture of glass, and which is skimmed off. It is also called *sandiver*.

GALLON. An English measure of capacity. By act of parliament the imperial gallon is to contain 10 lbs. avoirdupois of distilled water, weighed at the temperature of 62° of Fahrenheit, and the barometer standing at 30 inches. This is equivalent to 277·274 cubic inches. The old English gallon, wine measure, contained 231 cubic inches; beer measure, 282 cubic inches.

GALLIC ACID. (*See* GALL-NUTS) It is composed of 7 atoms of carbon, 8 atoms of hydrogen, and 5 atoms of oxygen.

GALL-NUTS. Excrescences produced by the *cynips*, a small insect which deposits its eggs in the tender shoots of the *Quercus infectoria*, a species of oak abundant in Asia Minor. When the maggot is hatched it produces a morbid excrescence of the surrounding parts, and ultimately eats its way out of the nidus thus formed. The best galls are imported from Aleppo and Smyrna; their principal ingredients are tan and gallic acid. The infusion of galls affords a dense white precipitate in solution of jelly, and a black precipitate with the persalts of iron. The latter property leads to the use of galls in the manufacture of ink and black dye; they are also used as an astringent in medicine.

Galls consist principally of three substances; tannin or tannic acid; yellow extractive; and gallic acid. Their decoction has a very astringent and unpleasant bitter taste. The following are their habitudes with various re-agents:—

Litmus paper is powerfully reddened.

Proto-chloride of tin produces an Isabel-yellow precipitate.

Alum; a yellowish gray precipitate.

Acetate of lead; a thick yellowish white precipitate.

Acetate of copper; a chocolate brown precipitate.

Ferric sulphate (red sulphate of iron); a blue precipitate.

Sulphuric acid; a dirty yellowish precipitate.

Acetic acid brightens the muddy decoction.

The galls of the *Quercus Cerris* and common oak are of a brown color, prickly on the surface, and irregular in shape and size. They are used chiefly for tanning in Hungary, Dalmatia, and the southern provinces of the Austrian states, where they abound.

Tannin or tannic acid is prepared as follows:—Into a long narrow glass adopter tube, shut at its lower orifice with a cotton wick, a quantity of pounded galls are put, and slightly pressed down. The tapering end of the tube being inserted into a matrass or bottle, the vacant upper half of the tube is filled with sulphuric ether, and then closed with a ground-glass stopper. Next day there will be found in the bottle in two distinct strata, of which the more limpid occupies the upper part, and the other, of a sirupy consistence and amber color, the lower. More ether must be filtered through the galls, till the thicker liquid ceases to augment. Both are now poured into a funnel, closed with the finger, and after the dense liquor is settled at the bottom, it is steadily run off into a capsule. This, after being washed repeatedly with ether, is to be transferred into a stove chamber, or placed under the receiver of an air-pump, to be evaporated. The residuary matter swells up in a spongy crystalline form of considerable brilliancy, sometimes colorless, but more frequently of a faintly yellowish hue.

This is pure tannin, which exists in galls to the amount of from 40 to 45 per cent. It is indispensable that the ether employed in the preceding process be previously agitated with water, or that it contain some water, because by using anhydrous ether, not a particle of tannin will be obtained.

Tannic acid is a white or yellowish solid, inodorous, extremely astringent, very soluble in water and alcohol, much less so in sulphuric ether, and uncrystallizable. Its watery solution, out of contact of air, undergoes no change; but if, in a very dilute state, it be left exposed to the atmosphere, it loses gradually its transparency, and lets fall a slightly grayish crystalline matter, consisting almost entirely of gallic acid. For procuring this acid in a perfectly pure state, it is merely necessary to treat that solution thus changed with animal charcoal, and to filter it, in a boiling state, through paper previously washed with dilute muriatic acid. The gallic acid will fall down in crystals as the liquid cools.

Gallic acid is always produced when any substance containing tannic acid is exposed to the air.

Tannin or tannic acid consists of carbon 51·56; hydrogen 4·20; oxygen 44·24.

Gallic acid does not exist ready formed in gallnuts, but that is produced by the reaction of atmospheric oxygen upon the tannin of these concretions.

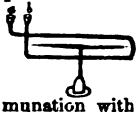
Gallic acid is a solid, feebly acidulous and styptic to the taste, inodorous, crystallizing in silky needles of the greatest whiteness; soluble in about 100 times its weight of cold, and in a much smaller quantity of boiling water; more soluble in alcohol than in water, but little so in sulphuric ether.

Gallic acid does not decompose the salts of protoxyde of iron, but it forms, with the sulphate of the peroxyde, a dark blue precipitate, much less insoluble than the tannate of iron. Gallic acid takes the oxyde from the acetate and nitrate of lead, and throws down a white gallate unchangeable in the air, when it is mixed with that acetate and nitrate. It occasions no precipitate in solutions of gelatine (isinglass or glue), by which its freedom from tannin is verified.

GALVANIZED IRON is the somewhat fantastic name newly given to iron tinned by a peculiar patent process, whereby it resists the rusting influence of damp air, and even moisture, much longer than ordinary tin plate. The following is the prescribed process. Clean the surface of the iron perfectly by the joint action of dilute acid and friction, plunge it into a bath of melted zinc, and stir it about till it be alloyed superficially with this metal; then take it out, and immerse it in a bath of tin, such as is used for making tin plate. The tin forms an exterior coat of alloy. When the metal thus prepared is exposed to humidity, the zinc is said to oxydize slowly by a galvanic action, and to protect the iron from rusting within it, whereby the outer tinned surface remains for a long period perfectly white, in circumstances under which iron tinned in the usual way would have been superficially browned and corroded with rust.

GALVANISM. (From Galvani, professor of anatomy at Bologna, the discoverer of some of the phenomomena connected with this form of electricity in the year 1790.) Under this term are frequently included the phenomena of *Voltaic electricity* (which see). We shall here limit it to the apparent evolution of electricity by the contact of different metals; this is best observed by the muscular contractions which are produced in the leg of a frog recently killed, when two different metals, such as zinc and silver, tin and gold, &c., one of which touches the crural nerve, and the other the muscles, are brought into contact. Every time the metals touch each other the limb become powerfully convulsed; and if the experiment be made with a dead rabbit, so that one of the metals be in contact with the brain, and the other with the muscles of the extremities, the whole body of the animal is strangely agitated. Similar experiments have been made upon the bodies of criminals shortly after execution. These results, which have till lately been considered to depend upon the effects of electricity excited by the contact of the metals upon the nervous and muscular systems, led Volta to his celebrated researches, which terminated in the discovery of the *Voltaic battery.* Nearly all the cases, however, of the apparent production of electricity by contact have been satisfactorily traced by Faraday to chemical action. (*See* VOLTAIC BATTERY.)

GALVANOMETER. An instrument for ascertaining the presence of a current of electricity, especially Galvanic or Voltaic electricity, by the deviation which it occasions in the magnetic needle. The simplest form of a galvanometer is a magnetic needle poised upon a point, and surrounded by one or more coils of copper wire covered with silk, the ends *a* and *b* being either left free, or terminating in two small copper cups containing mercury, for the convenience of communation with the source of electricity. When this needle is placed parallel to the coil, and in the magnetic meridian (as represented in the margin), it immediately deviates when the electric current passes through the coil; and the deviation is either to the east or west, according to the direction of the current. (*See* ELECTRO-MAGNETISM.)



GAMBOGE. A gum resin, concreted in the air from the milky juice which exudes from several trees. The *gambogia gutta*, a tree which grows wild upon the coasts of Ceylon and Malabar, produces the coarsest kind of gamboge; the *guttaefera vera* (*Stalagmites cambogioides*) of Ceylon and Siam affords the best. It comes to us in cylindrical lumps, which are outwardly brown yellow, but reddish yellow within, as also in cakes; it is opaque, easily reducible to powder, of specific gravity 1·207, scentless, and nearly devoid of taste, but leaves an acrid feeling in the throat. Its powder and watery emulsion are yellow.

GANGUE. A term to denote the stony matter which fills the cavities and accompanies the ores in the veins of metals.

GAS. When solid substances are rendered permanently aeriform by heat, the air thus produced is called a gas, to distinguish it from those substances which turn to the solid or fluid states when the heat is abstracted.

GAS (COAL) MANUFACTURE OF. The separation and purification of the volatile elastic fluids from pit coal, which have the property of giving out light when burned. They are various compounds of carbon and hydrogen, accompanied by hydrogen and carbonic oxide in large quantity.

The application of the gases produced during the destructive distillation of pit coal to the purposes of illumination is a very modern invention. But the germ of it may be traced back above 100 years; for the first mention of the production of a permanently elastic and inflammable gas from coal occurs in the *Philosophical Transactions* for 1739, in which there is a paper by the Rev. Dr. Clayton, describing a method of filling bladders with what he calls the *spirit of coal*, obtained by distilling coal in a retort in the open fire. He says, "I filled a good many bladders therewith, and might have filled an inconceivable number more; for the spirit continued to rise for several hours, and filled the bladders almost as fast as a man could have blown them with his mouth, and yet the quantity of coals distilled was inconsiderable. I kept this spirit in the bladders a considerable time, and endeavored several ways to condense it, but in vain; and when I had a mind to divert strangers or friends, I have frequently taken one of of these bladders and pricked a hole therein with a pin, and compressing gently the bladder near the flame of a candle till it once took fire, it would then continue flaming till all the spirit was compressed out of the bladder; which was the more surprising, because no one could discern any difference in the appearance between these bladders and those which are filled with common air." Dr. Clayton seems also to have observed those curious phenomena which have lately excited so much attention under the terms *exosmose* and *endosmose*; for he goes on to say that he found "that this spirit must be kept in good thick bladders, as in those of the ox or the like; for if I filled calves' bladders therewith, it would lose its inflammability in twenty-four hours, though the bladders become not relaxed at all."

Dr. Hales (in his *Vegetable Statics*) and Dr. Watson (in his *Chemical Essays*) have each alluded to the properties of the gas from coal; but it was not until the end of the last century that the practicability of substituting coal gas for other inflammables, as a means of lighting streets and buildings, became an object of attention.

The idea of applying coal gas to economical purposes seems first to have occurred in 1792 to Mr. William Murdoch, then residing at Redruth, in Cornwall. His apparatus consisted of an iron retort, with tinned copper and iron tubes, through which the gas was conducted to a considerable distance; and there, as well as at the intermediate points, was burned through apertures of varied forms and dimensions; he also washed the gas with water, and used other means for its purification. In 1798 Mr. Murdoch constructed a larger and improved apparatus for the purpose of lighting Boulton and Watt's celebrated manufactory at Soho, near Birmingham, which, on the occasion of the peace in 1802, was publicly illuminated by the same means.

In all extensive and well conducted establishments, the processes for the manufacture of gas are similar and uniform in the various stages. A great extent of ground is occupied with the retort house, purifying chambers, and space for the large gasometers. The arrangements are similar in all. They are, with slight exceptions, which we need not heed here, as follows:—Each side of the retort house has a succession of arched recesses, each eight or ten feet high, six or seven wide, and about as many in depth. These recesses, when bricked or otherwise closed in front, form ovens or furnaces, in which fuel is burnt on a grate at the lower part. Five, six, eight, or more oblong iron vessels, each holding from two to three bushels of coals, are ranged horizontally in this oven, from front to back, so that the heat, flame, and smoke from the surface may play around them, and make them red-hot. The outer end of these vessels, which are the *retorts*, are left opened or closed as occasion may require; an iron door, connected with a screw, being accurately fitted to each retort. The retorts are semi-cylindrical in shape, with the flat side placed lowermost. The average height of the retorts is perhaps about five feet from the ground; under them is a fireplace, through which the fuel is introduced by which they are heated; and under this again is a kind of ash-pit or shallow vessel into which the lime water is poured for the purpose of evaporation. The operation then consists in this:—The empty retorts are first brought to a red heat; then a 'charge of coals' is introduced; then the cover is screwed on the end, and made air-tight by a cement of clay and lime. Thus the retorts remain for about five hours, during which the fireplace is opened every hour for the renewal of the fuel with which the retorts are heated; and at the end of this time all the gaseous and vaporizable matters having left the coal, and passed up from each retort by a pipe into the 'hydraulic main,' the 'drawing of the retorts' commences. The retort-cover is loosened by turning a screw; a slight explosion takes place when communication with the atmosphere is opened; the cover is removed by the sooty and almost fire-proof hands of the men, and the coke is drawn out by means of rakes eight or ten feet long. A kind of box, made entirely of iron, and placed upon wheels, is wheeled beneath the front of the retorts, and into it a portion of the fiery contents of each retort is drawn. The box is wheeled away, and in a few minutes volumes of steam are ascending profusely from it, the result of a plentiful supply of water, which is thrown on it for the sake of speedy cooling. The remainder of the coke is then drawn out on the iron floor of the building, and, after being partially cooled by water, is removed out into the open air.

In the upper part of every retort is an opening from which ascends a vertical pipe three or four inches in diameter. The gas, as it is formed, having no other outlet, ascends this pipe, passes thence to another pipe placed horizontally, and then enters a descending pipe, which dips into a large main fourteen or fifteen inches in diameter. This main is placed horizontally along the whole length of the retort-house, and receives all the gas from the whole range of retorts on one side, there being two mains on opposite sides of each retort-house. In these mains commences that purification of the gas which is the object of four successive processes, carried on in four distinct kinds of apparatus, viz. the hydraulic mains, the condensers, the purifiers, and the saturators. As may be readily supposed, the transference of the various products, such as gas, tar, ammoniacal liquor, &c., from vessel to vessel, requires a large assemblage of pipes, some of which are carried underground, and others within view.

The retort-houses, such as have just been described, are four in number; two situated in the northern quadrangle, and the other two being placed parallel and contiguous in the central building of the southern quadrangle. To these a series of smaller rooms are attached to the southern end of the retort-houses, and within view from the entrance-gates. One of these is the office of the superintendent of the works, and the other two contain very ingenious specimens of apparatus whereby he can regulate the supply of gas at all hours of the day, calculate how much gas has been made within a certain period, ascertain the rate at which it is being manufactured at any particular time, and keep a check over the labors of the men. One of these rooms is called the 'valve-room,' and contains the apparatus for regulating the pressure and supply of the gas. To understand the use of such apparatus, it is necessary to recall to mind the striking change which occurs throughout a large city as evening is drawing on. The lamp-lighter is seen busily hastening from lamp to lamp, placing his slight ladder against the street lamp-irons, and kindling the flames which give to our streets no small share of their evening attractions; the shopkeeper begins to illuminate his wares, with one blaze if he be a humble dealer, with a dozen if his house be a 'gin-palace,' with a score or two if he sells 'unparalleled bargains' in linen drapery; the theatres, the club-houses, the evening exhibition-rooms—all begin to display a blaze of light near about one time. Now it must be obvious that the sudden demand thus created is enormous, and it may be easily conceived that great judgment is required in adjusting the supply. In order that the gas may be propelled through the main-pipes from the factory to the remotest point supplied from the works, it is necessary to give the gas a pressure or elastic force greater than that of the atmosphere. If this pressure be too small, the lights at remote places would burn much too faintly; if too large, the flames would become so strong as to consume an inordinate quantity of gas; if the gas flowed from the gasometers at an hour before dusk at the same rate as at an hour after dusk, the utmost confusion and irregularity would occur. To obviate these evils is the object of the pressure apparatus. Around the valve-room are placed valves connected with the great main. There are several mains branching out from the factory in as many different directions, for the supply of different parts of the town; and as each main requires a supply of gas proportionate to the nature and extent of the district through which it passes, a pressure-apparatus is attached to it distinct from the others. Directing attention to one main only, it may be stated that after the gas leaves the gasometers and enters the main, it is placed in communication with a small tube leading to a 'pressure-indicator,' by which the exact pressure at any time of the day or night is determined. So long as the pressure is such as is required, no changes are made; but when it is either too great or too small, recourse is had to a valve, whose interior apparatus is in connection with the main. If the pressure is too great, the valve is drawn partly across the main, by which the supply of gas is slackened: if too small, the valve is opened more than before, to admit a greater volume of gas. These adjustments are, as was before observed, made in the 'valve-room,' every main having its own 'pressure-indicator' and its own 'valve.'

A room adjacent to the one just mentioned, and called the "meter-room," exhibits to view a cast-iron case, about ten feet square, and seven or eight feet high, occupying the centre of the room. On the front are six or eight small dials, like clock-faces, and at the back are two pipes ascending through the floor, and entering the case. All the gas made at the works passes into this case or "meter" by one of the pipes just spoken of, and leaves it by the other. The meter will contain a certain known quantity of gas; and while this quantity is passing through the machine, an index hand is caused, by mechanism within the case, to revolve once round a dial-plate. Every ten revolutions of this hand causes another index to revolve once round another dial-plate; ten of these latter revolutions cause one revolution of a third index; and so on through six successive stages, the last index revolving only once while a million cubic feet of gas are passing through the meter. The superintendent, by looking at the indications in these six dial-faces, is thus able to tell, even to a single foot, how much gas has passed through the meter to the main pipes. There are two other dials on the front of the meter, one of which is a regular clock, and the other an ingenious arrangement for showing the rate at which the gas is passing through the meter at any particular time.

The operations of a gas factory are interminable from the beginning to the end of the year. No cessation, even for a moment, occurs in the labors. One party of men are engaged at night; another party relieve them after an interval of twelve hours, and are employed by day; but the furnaces are always heated, the retorts always supplied with their fiercely burning contents, the gas always undergoing the purifying processes previous to its passage into the gasometers. The number of retorts worked varies at different seasons of the year, according to the length of time between sunset and sunrise; for the gas-manufacturer is regulated, more perhaps than most other manufacturers, by the movements of the sun. But whether the number actually worked at any one time be greater or smaller, the system pursued is nearly the same. At the works we have noticed, the retorts are so divided into groups that some of them shall be ready for "drawing" every hour. If, for instance, a charge of coals remains five hours in the retort, and the retorts are divided into five parcels or sets, one set would be filled at noon, another at one o'clock, and the rest at two, three, and four respectively. Then, by five o'clock the first set of retorts are ready to be drawn; at six o'clock the second set; and so on with the others. The precise arrangements need not be entered into, but it will suffice to say that exactly as the clock strikes each successive hour, the men loosen and remove the covers of the retorts, draw out a portion of the coke into large iron boxes, draw out the rest upon the iron floor of the retort-house, throw water on the coke preparatory to its removal from the retort-house, recharge the retorts with fresh coal, replenish the fires with a fresh supply of coke, and fit the covers—coated on their inner surface with a thick layer of lime and clay cement—firmly on the mouths of the retorts. In the intervals which elapse between the successive "drawings," the men are employed in pouring the lime-water into the troughs beneath the fireplaces, in placing new layers of cement on the retort-covers to be used after the next drawing, in carrying out the coke into the open air, and afterwards into the sheds or stores, in bringing coals from the coal-stores to the retort-houses, in removing the ashes which fall into the lime-water in the ash-pit, and in various other duties subsidiary to the manufacture of gas. The subsequent preparation, or rather perfecting of the gas, demands but a small amount of manual labor; it is in fact performed by the steam-engine, which pumps up the water from the well, transfers from vessel to vessel the tar and the ammoniacal liquor abstracted from the gas, and sets in rotation the arms or fans in the purifying vessels.

There is perhaps no part of the gas mechanism which requires better workmanship and more careful attention than the pipes which convey the invisible agent from the works to the places where it is consumed. However perfect may be the mode in which the gas is manufactured, however plentiful the supply, yet if the pipes are either too small or too large, if they are laid either too horizontal or too much inclined, if any of the innumerable joints are imperfectly fitted, the most serious inconvenience results. The mains vary from three inches to eighteen inches in diameter, independent of the small lateral pipes which proceed from the mains into the houses. The largest mains are placed nearest to the gas-works; the next in size are appropriated to the leading streets and thoroughfares; while the smaller are for the less important lanes and streets. Where the streets are wide, and the number of lights required large, it is usual to lay mains on both sides of the street; and the diameters of these mains are made to depend not only on the magnitude and importance of the street, but on its elevation, its distance from the works, and other circumstances. There is a circumstance attended to in laying down the mains which is perhaps not generally known. They are laid with a gradual inclination, amounting perhaps to an inch in ten or twelve yards, instead of being horizontal; and when this slope has continued for one or two hundred yards, the mains begin to ascend in a similar degree. The line of mains thus ascends and descends alternately throughout its whole length. The reason for this arrangement is, that a small deposition of fluid takes place in the mains; and this fluid, by flowing down the inclined pipes, accumulates at the lower points, where two descending lines meet; here a reservoir is formed, into which the liquid flows, and by the occasional use of a small pump from above the inconvenience is removed.

When gas is made from coal, the selection of the coal becomes an object. The most bituminous is most desirable, and what is termed Cannel coal is usually preferred. The Philadelphia Gas Company use Virginia (Richmond) coal, while the two New York companies use two parts of Cannel coal and one part of Newcastle. The compositions of these two varieties are given, by Richardson—

	Newcastle.		Cannel.
Carbon......	84·846	.....	67·597
Hydrogen	5·048	......	5·405
Oxygen Nitrogen } ..	8·430	......	12·432

When these coals are heated to redness in closed vessels, the following process results:—A coaly residue (coke) remains, and certain volatile products escape, which partly condense on cooling into tar and an aqueous fluid, while the rest is a mixture of gases, but contains also no inconsiderable portion of the volatile vapors of different compounds, which remain dissolved in the coal gases without being condensed into liquids. These are oily products, mostly hydro-carbons, with a large proportion of carbon; to these belong kyanol, leucol, pyrole, rosolic and carbonic acids and napthaline; most of these contain 90 per cent. of carbon, napthaline as much as 94 per cent., and in burning they deposit it in greater quantity than olefiant gas. These, therefore, enhance very much the illuminating power of the gas. Illuminating gas is not a definite compound of one or two gases, as carburetted hydrogen or olefiant gas, but a mechanical mixture of very various bodies, some of which are only slightly luminous, some absolutely prejudicial for illumination, whilst others are exceedingly luminous, as olefiant gas and the carbo-hydrogens, possessing similar properties, and to which the mixture owes its illuminating properties. By distilling coal, we have left behind the solid coke in the retort, and then are given off, as volatile matters, a number of gases, vapors, and liquids which separate in their passage, and are received in the tar-cistern and condenser. The liquids consist of, first, *coal tar*, which, on redistilling, yields pitch, coal oil (naptha), containing the hydro-carbons noticed above; and, second, of *ammoniacal liquor*, containing water, hydro-sulphate, carbonate, muriate, acetate, hydrocyanate, sulphite, and gallate of ammonia.

The gases and vapors may be divided into three classes. First, those separated by the lime purifier, viz. carbonic, hydrosulphuric, and hydrocyanic acids and ammonia. Second, those separated by water or in the alum, or green vitriol purifier, viz. ammonia (and hydrocyanic acid by green vitriol). Third, those which pass on to the gasometer, viz. trace of naptha vapor, trace of vapor of sulphuret carbon, nitrogen, hydrogen, carbonic oxide, light carburetted hydrogen, and olefiant gas.

These numerous substances are not afforded in the same relative proportions, at the same periods of the distillation. On the first application of the heat to coal, steam, along with the air of the retort, comes off; as the heat approaches redness, tar is disengaged, but only a small proportion of gas *below a red heat;* and such gas has a feeble illuminating power; when the retort is heated bright red, the evolution of gas is at its maximum, but tar is still produced, though slowly. At a white heat, carried on for two hours, the tar is small in proportion, that of the gas is still large, but decreasing. At length, the gas ceases to be given off. Mr. Peckston's table, showing the relative amount of gas given off from one chaldron of Newcastle coal at different periods of the process, illustrates this—

In	1st.	hour	2000	cubic	feet.
"	2d.	"	1495	"	"
"	3d.	"	1387	"	"
"	4th.	"	1279	"	"
"	5th.	"	1189	"	"
"	6th.	"	 991	"	"
"	7th.	"	 884	"	"
"	8th.	"	 775	"	"
Total in 8 hours			10,000	cubic	feet.

The composition and illuminating power of gas produced at different periods of the process, vary considerably. The gas evolved before the retort is red hot, contains a great deal of carbonic oxide, hence its feeble illuminating power; that produced at a bright red heat contains a larger portion of olefiant gas and vapors of hydro-carbons, than what is formed at a higher or lower temperature. As distillation advances the temperature increases; the proportion of illuminating gas decreases, while that of carbonic oxide and hydrogen increases in proportion. The density of the gas is also in some degree in proportion to its illuminating power, but decreases as the heat advances. Dr. Henry's table, here annexed, shows the nature of the gas evolved from Cannel coal, at different periods of the process:—

	1	2	3	4	5
Olefiant gas and vapors of hydro-carbons........	13	12.	12.	7·	—
Light carburetted hydrogen	82·5	72·	58·	56·	20·
Carbonic oxide....	3·2	1·9	12·3	11·	10.
Hydrogen...........	—	8·8	16·	21·3	60·
Nitrogen gas.....	—	5·3	1·7	4·7	10·
		100.0	100·0	100·0	100.0

No. 1, 2, and 3 were produced during the first hour, 4 at the commencement of the 6th hour, and No. 5 10 hours from beginning.

After those various liquid and gaseous substances are obtained, they have to be separated so as to isolate the illuminating gases: the first step is to pass the whole of the volatile matters through the condenser. The warm gases which issue [have a tendency to condense and stop up the tubes] are conducted to the *coolers* or *condensers*, which are of various construction. Ordinarily it consists of an iron chest filled with water, and having a false bottom; a series of tubes connected by saddle joints are in the box. The lower part of this is divided into cells in which the fluids collect until they reach the level of a drawing-off tube, and they are thus separated —other condensers consist of a high perpendicular tank, with a system of zig-zag gas tubes, over which an uninterrupted shower of water rains from above. On leaving the condenser the whole of the gases are still retained; several of those are useless, as carbonic oxide and hydrogen, which burn with a very slight evolution of light, and only tend to dilute the gas: others, on the contrary, are detrimental, as ammonia, combined with carbonic, muriatic, and sulphuric and sulphurous acids and sulphuretted hydrogen. The purification of the gas only removes the latter class, not the former.

The lime purifier consists of a chamber containing milk of lime, stirred up with water, and agitated with a stirrer: the gas is passed through it in a very fine stream of bubbles. This removes the carbonic acid and sulphuretted hydrogen, but appears to diminish the illuminating power of the gases. To separate the ammonia a solution of alum is sometimes used. Protosulphate of iron has been used for the same purpose. Dilute sulphuric acid removes the ammonia much more rapidly, forming a sulphate of ammonia, which is produced in gas works in large quantity, and is sold either to farmers as manure, or to manufacturers for the formation of other salts of ammonia. Washing the gas with water, will by itself separate the ammonia. Mullet proposes to transmit the gas through two purifiers, one a solution of green vitriol or sulphate of manganese, and the other one of milk of lime. This is the most profitable and least laborious plan.

When gas has been thus prepared and purified, it has a composition variable as the coal used, and the heat and time of the operation. The composition marked No. 1 in Henry's table, is a very pure gas. During the present year, while public attention in New York was turned toward the cost and purity of gas, the two gas companies of that city (the Manhattan Co. and the New York Co.) jointly requested Drs. Torrey, Ellet, and Chilton, to undertake a thorough investigation and analysis of the gases of both companies, as well as that of the Philadelphia City Gas Co., and the report of these chemists appeared on the 22d May. The plan of their investigation and character of the experiments were those most likely to insure accuracy and involve means of detection not previously used in Europe. The following is an abstract from their report:—

"The following we believe represents the true constitution of the Philadelphia gas, as delivered to the consumers from April 15th to April 24th, and of the Manhattan and New York Companies' gases from April 24th to May 22d.

		Philadelphia.	New York Gas Light Company.	Manhattan Gas Light Company.
Condensible by Chlorine,	Olefiant Gas,	2.30	5.66	5.60
	Hydro-Carbon Vapors	4.20	6.85	6.40
Light Carburetted Hydrogen		37.75	42 10	48.00
Carbonic Oxide.............		7·50	8.40	7.50
Hydrogen....................		45.38	33.20	80.20
Nitrogen....................		2.87	3.80	2.30
		100.00	100.00	100.00

"All of the gases are effectually cleansed from carbonic acid and from sulphuretted hydrogen, not the slightest traces of either of them being discernible by the most delicate re-agents. The lime purifiers seem to perform their office thoroughly, and the gases have a less offensive odor than was formerly the case. Ammonia has been detected in all of them, but the quantity is very minute, and has not yet been estimated.

"It will be seen from the above results that the New York gases resemble each other very closely, (as might have been anticipated,) since their manufacture is conducted as nearly as possible in the same way, and the materials employed in their production are the same, viz., two-thirds of Cannel coal, and one-third of Newcastle coal. They have both an advantage over the Philadelphia gas in the greater relative quantity of their two most valuable constituents, viz., olefiant gas, and hydro-carbon vapors.

"Photometrical processes are obviously the most reliable for determining the relative *illuminating value* of different gases, and they accordingly have not been neglected by us. The comparisons have been made by means of a standard candle of Judd's manufacture, which itself has been compared with a standard candle used in the English gas works, and which had been employed within a few months in determining the relative value of their products. We have thus been enabled to compare the illuminating values of the American gases on which we have experimented, not only with each other, but also with those of Great Britain. It results from our experiments that no appreciable difference in this respect exists in the New York gases, the slight excess of olefiant gas and hydro-carbon vapors in the one, being compensated by the greater quantity of light carburetted hydrogen in the other.

"The quality of these gases we believe to be better than that of most of those manufactured in the principal cities of Great Britain, and if excelled by any of them, it is only by those which are derived from pure Cannel coal.

"We find that the New York gases are of decidedly superior value to that manufactured in Philadelphia, and that to obtain a certain definite *quantity of light*, we must employ them in quantities represented by the following numbers—of

Manhattan Gas,	100	cubic feet,
New York Company's Gas	100	" "
Philadelphia Gas,	152.3	" "

"*The values of these gases as sources of light are of course inversely as these numbers.*

"We do not attach much importance to specific gravity as exhibiting the worth of an illuminating gas. Carbonic oxide, and nitrogen, (the one of very little value, and the other absolutely worthless,) are always present in these gases, and are both identical in specific gravity with olefiant gas, which is one of their most valuable constituents; a circumstance which renders the test an unreliable one, except in connection with other characters. We have, however, made many trials on these gases, and have found that the specific gravity of the Philadelphia gas is below 450, while that of both the Manhattan and New York Companies' gases is on the average 550, atmospheric air being 1000.

Good gas furnished at moderate prices is still a desideratum, and has led to the use of camphene and water gas manufactured on a small scale. The cost of coal gas might be diminished by the sale of the waste substances produced as Coke, Sulphate of Ammonia, Gas Lime, and Tar. (*See* OIL GAS, RESIN GAS, AND WATER GAS.)

GAUGE-POINT, is a term used in gauging to denote the diameter of a cylinder whose altitude is one inch, and its contents equal to that of a unit of a given measure. For example, the old wine gallon contained 821 cubic inches. The diameter of a cylinder of the same capacity, and whose altitude is one inch, is 17·15 inches; which, therefore, is the gauge-point for this measure.

GAUGING, in mensuration, is the measuring of the capacities of vessels, chiefly casks, barrels, vats, &c., and determining the contents of the substances contained in them. The principles of gauging are those which geometry furnishes for the measurement of solids in general; but as the contents of vessels of the kind now mentioned are so frequently required to be known, at least approximately, for the purposes of commerce and the collection of the revenue, a set of technical rules and appropriate instruments have been contrived, by the help of which the art can be, and generally is, practised mechanically by those who are utterly ignorant of the principles on which it depends. The instrument generally used for the purpose is the *gauging-rod*, or *diagonal-rod*, by which the contents of a cask are inferred from its diagonal length, measured from the bung to the extremity of the opposite stave at the head. On one face of a square rule, generally about four feet long, is a scale of inches for taking the measure of the diagonal; and on the opposite face is a scale expressing the corresponding contents of the cask in gallons. It is obvious that this method of proceeding can only give approximate results, on the supposition that all casks are similar solids.

GELATINE is an animal product which is never found in the humors, but it may be obtained by boiling with water the soft and solid parts; as the muscles, the skin, the cartilages, bones, ligaments, tendons, and membranes. Isinglass consists almost entirely of gelatine. This substance is very soluble in boiling water; the solution forms a tremulous mass of jelly when it cools. Cold water has little action upon gelatine. Alcohol and tannin (tannic acid, *see* GALL-NUTS) precipitate gelatine from its solution; the former by abstracting the water, the latter by combining with the substance itself into an insoluble compound, of the nature of leather. No other acid, except the tannic, and no alkali possesses the property of precipitating gelatine. But chlorine and certain salts render its solution more or less turbid; as the nitrate and bi-chloride of mercury, the proto-chloride of tin, and a few others. Sulphuric acid converts a solution of gelatine at a boiling heat into sugar. (*See* LIGNEOUS FIBRE.) Gelatine consists of carbon, 47·88; hydrogen, 7·91; oxygen, 27·21 (*See* GLUE.)

Gelatine brut fin, is from the skulls, blade-bones, and shank-bones of sheep, the ends cut off, the bones cut down the middle to remove the fat, steeped in muriatic acid, then in boiling water a few minutes, wiped carefully, dried, shaken together in a bag to remove the internal pellicle, cut across, or into dice, to disguise them, and finally dipped in a hot solution of gelatine to varnish them. It is used to make soup, keeps better than the cakes of portable soup; and, less carefully prepared, makes carpenters' glue for fine work.

Very recently, a very beautiful sparkling gelatine has been prepared under a patent granted to Messrs. J. & G. Cox, of Edinburgh. By their process the substance is rendered perfectly pure, while it possesses a gelatinizing force superior even to isinglass. It makes a splendid calves' feet jelly and a milk-white blancmange. The patentees also prepare a semi-solid gelatine, resembling jujubes, which readily dissolves in warm water, as also in the mouth, and may be employed to make an extemporaneous jelly.

The gelatine of bones may be extracted best by the combined action of steam and a current of water trickling over their crushed fragments in a properly constructed apparatus. When the gelatine is to be used as an alimentary article, the bones ought to be quite fresh, well preserved in brine, or to be dried strongly by a stove. Bones are best crushed by passing them between grooved iron rolls. The cast-iron cylinders in which they are to be steamed, should be three times greater in length than in diameter. To obtain 1,000 rations of gelatinous soup daily, a charge of four cylinders is required; each being 3¼ feet long, by 14 inches wide, capable of holding 70 lbs. of bones. These will yield each hour about 20 gallons of a strong jelly, and will require nearly 1 gallon of water in the form of steam, and 5 gallons of water to be passed through them in the liquid state. The 5 quarts of jelly produced hourly by each cylinder, proceeds from the 1 quart of steam-water and 4 quarts of percolating water.

GEMS are precious stones, which, by their color, limpidity, lustre, brilliant polish, purity, and rarity, are sought after as objects of dress and decoration. They form the principal part of the crown jewels of kings, not only from their beauty, but because they are supposed to comprise the greatest value in the smallest bulk; for a diamond, no larger than a nut or an acorn, may be the representative sign of the territorial value of a whole country, the equivalent in commercial exchange of a hundred fortunes, acquired by severe toils and privations.

Among these beautiful minerals mankind have agreed in forming a secret class, to which the title of *gems* or *jewels* has been appropriated; while the term *precious stones* is more particularly given to substances which often occur under a more considerable volume than *fine stones* ever do.

Diamonds, sapphires, emeralds, rubies, topazes, hyacinths, and chrysoberyls, are reckoned the most valuable *gems*.

Crystalline quartz, pellucid, opalescent, or of various hues, amethyst, lapis lazuli, malachite, jasper, agate, &c., are ranked in the much more numerous and inferior class of ornamental stones. These distinctions are not founded upon any strict philosophical principle, but are regulated by a conventional agreement, not very well defined; for it is impossible to subject these creatures of fashion and taste to the rigid subdivisions of science. We have only to consider the value currently attached to them, and take care not to confound two stones of the same color, but which may be very differently prized by the *virtuoso*.

GEMS, ARTIFICIAL. These are made of a very fusible, transparent, and dense glass, or *paste*, as it is called, containing a large proportion of oxide of lead, and generally some borax: the colors are given by metallic oxides. Much of their perfection depends upon the skill with which the exact tint of the real stone is imitated, and upon the care with which they are cut and polished.

Mr. Ebelman, Director of the National Porcelain Manufactory of Sevres, has dissolved in boric acid, alum, zinc, magnesia, oxides of iron and chrome, and then subjecting the solution to evaporation during three days, he has obtained crystals equalling in hardness, clearness, and beauty the natural stones. With chrome he has made most brilliant rubies, from two to three millimetres in length, and as thick as a grain of corn. He has also made artificially, diaphonous quartz, hydrophane, and chalcedony.

GENEVA, or Hollands gin, is made by mashing 120 lbs. of malt with 240 lbs. of rye flour, in 480 gallons of water at 162°. Yeast is added at 80°: and in two days the fermentation raises it to 90°. The whole, grains and all, is then subjected to three distillations, and before the last, juniper berries and hops are infused.

GEODES. Round masses or nodules of iron-stone, hollowed in the centre. Rounded pebbles having an internal cavity, lined with crystals, are also so called.

GEODESY. A word occasionally used, which literally signifies the *division of the earth*, in which sense it is synonymous with land surveying; but it is usually employed in a more general sense to denote that part of practical geometry which has for its object the determination of the magnitude and figure either of the whole earth, or of any given portion of its surface. In this sense it comprehends all the geometrical or trigonometrical operations that are necessary for constructing a map of a country, measuring the lengths of degrees, &c. In order to construct an accurate map, or determine the form and dimensions of a country, it is necessary, in the first place, to determine the absolute distances between the several stations or points; secondly, to determine the azimuths of the lines thus measured, that is, their situation with respect to the meridian; and thirdly, the differences of latitude and longitude of the stations. The operations necessary for determining the absolute distances, comprehending the measurement of a base, the observation of angles, the computation of the sides of the triangles, and their reduction to the same level, are called the *geodesical* or *geodetical* operations; while those which are required for determining the azimuths and latitudes are called the *astronomical* operations. The determination of the figure and dimensions of the earth is a problem of very great importance to astronomy and geography, and has accordingly at all times been a subject of much interest to mathematicians; but it is only since towards the middle of the last century that operations on an adequate scale for its solution have been undertaken in different parts of the world. Further details do not come within the scope of this volume. *See* THEODOLITE.

GERMAN SILVER. *See* close of the article COPPER.

GERMINATION, or BUDDING. The process by which a plant is produced from a seed. The phenomena of germination are best observed in dicotyledonous seeds; such, for instance, as the bean, pea, lupin, &c. These seeds consist of two lobes or cotyledons, enveloped in a common membrane; when this is removed a small projecting body is seen, which is that part of the *germ* which afterwards becomes the root, and is termed the *radicle*: the other portion of the germ is seen on carefully separating the cotyledons, and is termed the *plumula*; it afterwards forms the stem and leaves. When the ripe seed is removed from the parent plant it gradually dries, and may be kept often for an indefinite period without undergoing any change; but if placed under circumstances favorable to its germination, it soon begins to grow: these requisite circumstances are a due temperature, moisture, and the presence of air. The most favorable temperature is between 60° and 80°; at the freezing point none of the more perfect seeds vegetate; and at temperatures above 100°, the young germ is usually injured. No seed will grow without moisture: water is at first absorbed by the pores of the external covering, and decomposed; the seed gradually swells, its membranes burst, and the germ expands. The root is at first most rapidly developed, the materials for its growth being derived from the cotyledons; and when it shoots out its fibres or rootlets, these absorb nourishment from the soil, and the plumula is developed, rising upwards in a contrary direction to the root, and expanding into stem and leaves. For this growth the presence of air is requisite; if it be carefully excluded, though there be heat and moisture, yet the seed will not vegetate. Hence it is that seeds buried very deep in the earth, or in a stiff clay, remain inert; but, on admission of air by turning up the soil, begin to shoot forth. From experiments which have been made upon the germination of seeds in confined atmospheres, it appears that the oxygen set free by the decomposition of water combines with a portion of the carbon of the seed, and carries it off in the form of carbonic acid, and that the consequence of this is the conversion of part of the albumen and starch of the cotyledons into gum and sugar; so that most seeds, as we see in the conversion of barley into malt, become sweet during germination. Light is injurious to the growth of a seed. It is, therefore, obvious that the different requisites for germination are attained by placing a seed under the surface of the soil warmed by the sun's rays, when it is moistened by its humidity and by occasional showers: excluded from light, but within reach of the access of air.

When the young plant is perfected,

the cotyledons, if not coverted into leaves, rot away, and the process of nutrition is carried on by the root and leaves: the principal nourishment is taken up from the soil by the root, and chiefly by its small and extreme fibres; so that when these are injured or torn, as by careless transplantation, the plant or tree generally dies. The matters absorbed, consisting of water holding small portions of saline substances, and of organic matter in solution, become the *sap* of the plant; and this is propelled upwards in the vessels of the stem, or of the outer layer of wood, into the leaves; here it is exposed to the agency of air, or of light: it transpires moisture, and occasionally carbonic acid. But the leaves also at times absorb moisture, and during the influence of light they decompose the carbonic acid, and, retaining the carbon, evolve oxygen; the sap thus becomes modified in its composition, and the characteristic proximate principles of the vegetable are formed. These return in appropriate vessels from the leaves, chiefly to the inner bark, where we accordingly find the accumulation of the peculiar products of the plant: they also enable it annually to form a new layer of wood. Hence it is that the transverse section of the wood exhibits as many distinct zones as the tree is years old. We are ignorant of the causes of this circulation of the sap; but that it does follow the cause which has been stated is proved by the operation which gardeners call *ringing*, and which they sometimes resort to, to make a barren branch bear flowers and fruit: it consists in cutting out and removing a circular ring of bark, so as to prevent the return of the sap by the descending vessels, which at first ooze copiously, but afterwards the wound heals, and the juices are accumulated in all parts above the extirpated ring, producing tumefaction in the limb, and often inducing a crop of flowers and fruit, or causing those to appear earlier than on the uncut branches. If a tree be wounded so as to cut into the central portions of the wood, or the outer layer of new wood, the flow of ascending sap is then seen to take place upon the lower section, where the vessels are that carry it up to the leaves; and the flow of descending sap is principally confined to the upper section of the inner bark, from which, after a time, new bark is produced, and the parts again united.

GIG. A well-known kind of light carriage drawn by one horse. *Gigs*, or *gig machines*, are rotatory cylinders covered with wire-teeth, for teazling woollen cloth.

GILDING. The application of a superficial coat of gold on wood, metal, and other materials. The beauty and durability of gold render it the most valuable of all ornamental substances; but, on account of its weight and high price, its use in these respects would be exceedingly limited, were it not the most extensible and divisible form of matter, so that it may be made to cover a larger surface than an equal quantity of any other body. Metals are usually covered with gold by the process of *water gilding*. It consists in perfectly cleaning their surface, and then, in the case of silver, for instance, rubbing it over with a solution of gold in mercury, called *amalgam of gold:* the vessel is then heated over a clear charcoal fire, by which the mercury is driven off, and the gold left adhering to the silver surface, upon which it is afterwards burnished. The surface of copper or brass is usually prepared by cleaning and rubbing it over with a solution of nitrate of mercury, which amalgamates the surface, and enables the gold amalgam, when subsequently applied, to adhere; heating and burnishing are then resorted to as before. Brass and copper buttons are gilt in this way; and the requisite quantity of gold is so small that twelve dozen buttons of one inch diameter may be completely gilt upon both surfaces by five grains of gold. Other kinds of gilding are performed by gold leaf, which, if intended for out-door work, is laid on by the help of *gold size*, which is drying oil mixed with calcined red ochre; or, if for picture and looking-glass frames, they are prepared by a size made by boiling parchment clippings to a stiff jelly, and mixed with fine Paris-plaster or yellow ochre. The leaves of books are gilt upon the edges by brushing them over, while in the binder's press, with a composition of four parts of Arminian bole and one of powdered sugar candy mixed up with white of egg: this coating, when nearly dry, is smoothed by the burnisher, then slightly moistened, and the gold-leaf applied and burnished. To impress gilt figures on book covers, the leather is dusted over with finely-powdered mastic: the iron tool by which the figure is made is then moderately heated and pressed upon a piece of leaf-gold, which slightly adheres to it.

In *gilding wood*, the operator should

be provided with a cushion, made of a board about 10 inches square, covered with leather, and lightly stuffed with cotton, and a thumb-piece at the back; also, with a *tip*-brush, a pallet-knife, and a dabber, or silk bag filled with cotton. The pattern to be gilt is then exactly washed with jappanner's gold size, (linseed-oil and gum animi, thinned with oil of turpentine,) and the gold leaves being cut on the cushion with the pallet-knife, are transferred by the tip-brush to the sized surface and tapped with the silk bag, and left to dry.

In covering surfaces with gold, the size is made of 8 boiled oil, 1 japanner's gold size, with yellow ochre ground in boiled oil. Two separate washes of this must be applied to the pattern, and before quite hard, the gold-leaf laid on. Other size is made by grinding red lead with thick drying-oil, and diluting with turpentine; and, in other cases, with mere glue.

Iron and steel are gilt by simply dipping. The solution in aqua-regia is to be evaporated till it crystallizes, and then, if dissolved in water and alcohol, the iron may be dipped. But, if sulphuric ether be added, polished steel will be gilt by simple immersion.

Silver is gilt by a solution of the gold in a menstruum of nitric acid, sal ammoniac, and corrosive sublimate. It blackens the silver, but a red heat restores the gold color.

The mercurial amalgam can be applied to copper, or brass, or silver, by washing the surface with a solution of dilute sulphuric acid and mercury. The amalgam is then evenly applied with a wet brush of brass wire. The heat of a furnace evaporates the mercury, and leaves the gold. Rub with gilders' wax, and burnish with steel.

Iron is gilt by heating it blue, and laying on the gold-leaf, burnishing, and heating. Repeat till perfect.

Copper buttons are gilt by putting them in nitric acid, and then burnishing on hard stone. Then stir them in nitric solution of mercury till white. The amalgam of gold is then mixed with nitric acid, and the buttons being well stirred the gold attaches. By heating, the mercury is made to run, when, after trituration in a hairy bag, further heat evaporates it, and the buttons are burnished.

Gilding in cornices, &c., is effected by priming with boiled linseed-oil, and carbonate of lead. The surface is then covered with gold size, on which slips of gold-leaf are pressed with cotton. The edges are then brushed off. Burnished gilding requires priming with gum, and bole must be mixed with the gold size.

Gilding in oil.—1. The first operation is to give a priming coat of color, formed by grinding white lead in oil, rendered drying by boiling with litharge, and tempered afterwards with linseed-oil, adding a little fat oil, and a very small portion of spirits of turpentine. 2. Grind calcined white lead very fine in fat oil; this must immediately be tempered with oil of turpentine, as it is subject to become thick very quickly. Three or four thin coats of this are to be given very evenly in the ornaments, and in all parts intended to be gilt. Care must be taken in applying the color to the deeper parts of the work, that it may be even and perfect.—This is the *teinte dure*, or hard ground. 3. The gold color or size, previously strained through fine linen, is then to be laid on, very thin and even, with a soft brush which has been used for oil colors. A smaller brush must be used for the deeper parts of the sculptured or other ornaments, carefully observing to remove any hairs which may be detached from the brush. 4. Where the size is so far dried as to become tacky, the gold leaf is to be spread upon the cushion, and divided with the knife; the gold is placed on with a small block of wood, faced with cloth, called a *palette*, and lightly pressed with cotton, repairing where necessary with pieces of gold cut small, applied by a badger's hair-pencil. 5. If the articles gilt are to be exposed to the weather, as balconies, gratings, statues, &c., they ought not to be varnished, as gilding in oil is more durable without than with varnish. The heat of the sun will, after a heavy rain, cause gilding covered with varnish to craze or crack over its whole surface. Gilding in the interior of a building, as on the rails of staircases, &c., should have a coat of spirit of wine varnish, drying it by means of a chafing-dish, and then applying a coat of oil varnish. The beauty of oil-gilding depends greatly upon the manner of varnishing it.

For gilding metal buttons.—To 4 oz. of yellow melted bees'-wax add, in fine powder, 1½ oz. of red ochre, 1½ oz. of verdigris, calcined till it yields no fumes, and ½ oz. of calcined borax, and mix them well. It is necessary to calcine the verdigris.

To exalt the color of green gold.—Take saltpetre 1 oz. 10 dwts., sal-ammoniac 1 oz. 4 dwts., and verdigris 18 dwts., and dissolve a portion of the mixture in water, as occasion requires.

To exalt the color of yellow gold.—Take saltpetre 6 oz., green copperas 2 oz., white vitriol and alum, of each 1 oz. If the color be wanted redder, a small portion of blue vitriol must be added. To be dissolved in water, as wanted.

These two last compositions must be applied to the surfaces of the gilt works, either with a pencil, or by dipping them; a proper degree of heat must then be used to cause them to assume a black color, when they must be quenched, or cooled, either in vinegar or water.

Gilding japan-work is performed with japanner's gold size; and for dead gold it should be used with turpentine only, but for lustre with fat oil only.

Gilding earthenware and porcelain.—Take 2 drs. or 5 dwts. of pure gold and triturate in a porcelain mortar carefully, until very fine; add, at distinct times, 1, 2, and 3 dwts. of pure mercury, and mix well together; then add 10 grs. of white oxide of lead. *Or*, exclude the lead, and 1 dwt. of the mercury, when a strong body of gold is required.

On a glass plate, long, and very carefully grind for use.

When the gold (as on some occasions) contains an alloy of silver, less mercury must be taken, and lead wholly excluded.

In executing the superior specimens of this art, men are employed; and in many of the porcelain manufactories may be seen specimens of the high excellence of which it is susceptible, in flowers, landscapes, and portraits. Other less delicate patterns are the work of young women; of whom, great numbers provide for their comforts by these employments.

When the *gilded* ware has been through the muffle, and is cool, the gold is burnished with agate or bloodstone; the ware is then wrapped in tissue paper, and carefully packed for home, or foreign markets.

On some of the least valuable porcelain, leaf-gold is fixed by being placed on a warm size, formed of these components. Boil together half a pint of pure linseed-oil, ¼ oz. of gum arabic, gum benzoin, and acetate of lead severally; and after being well boiled, cool; lay evenly on the ware, heat the whole a little, add the strips of leaf-gold, and carefully place for sale.

To gild with burnished gold.—Give five or six coats of size and whiting. First with varnish of Armenian bole, wax and size. Wet with water, and lay on the gold, and in a few hours burnish with agate.

To gild the edges of books.—Wash them, in the press, with Armenian bole, sugar candy, and white of eggs. Wet with water and lay on the gold leaf, and burnish with a dog's tooth, or steel tooth.

Golden articles of jewelry.—The two best mixtures for the purpose of giving a good gold color to articles of jewelry, are as follows:—

	PARTS.
Muriatic acid at 22°	10
Oil of vitriol	4
Crystallized boracic acid	2
Water	150

Or,

Acid muriate of alumine (liquid)	13
Crystallized sulphate of soda	4
Crystallized boracic acid	3
Water	150

Either of these mixtures, with 20 grs. of neutral muriate of gold, constitutes the bath, which is to be used in the following manner:—A large glass mattrass, carefully luted at the bottom, is placed over a circular furnace, so as to have heat readily applied to it; the solution is to be be put into it, and when at the boiling point, the pieces of jewelry, previously cleaned and picked, are to be introduced, suspended upon golden wires. After a few minutes, a copper wire is to be immersed, and left until the gold has acquired a deep color; it is then to be withdrawn, but the articles still left in until they have acquired the color necessary. They are then to be put into warm water, acidulated by sulphuric or acetic acid, to remove particles of oxide of copper, washed in clean warm water, and dried near a fire. Generally, a single operation is not enough; for, as a long immersion produces harm from the oxide of copper, it is better to shorten it, and repeat the operation.

Gold size.—Mix 16 oz. of linseed-oil, 8 oz. of turpentine, 2 oz. of asphaltum, and 1 oz. each of brown umber and of red lead. *Or*, melt together 1 oz. each gum asphaltum and anime; ¼ oz. each of litharge, red lead, and brown umber; 4 oz. of linseed-oil and 8 oz. of drying-oil; strain.

Gilders' wax is 4 lbs. of bees'-wax, a ¼ of verdigris, and also of sulphate of copper, kept in a red heat until the wax has evaporated.

Shell gold may be obtained by amalgamating the metal with 8 parts of mercury in a crucible, and then evaporating the mercury. *Or*, gold leaf may be triturated with gum-water, and the gum dissolved and poured off.

GIMBALS, or GIMBOLS. A piece of mechanism consisting of two brass hoops or rings, which move within one another, each perpendicularly to its plane, about two axes placed at right angles to each other.

GLANCE COAL. Anthracite: it is subdived into two classes—1st, the slaty; and 2d, the conchoidal.

GLASS is a transparent solid formed by the fusion of silicious and alkaline matter. It was known to the Phenicians, and constituted for a long time an exclusive manufacture of that people, in consequence of its ingredients, natron, sand, and fuel, abounding upon their coasts. It is probable that the more ancient Egyptians were unacquainted with glass, for we find no mention of it in the writings of Moses. But according to Pliny and Strabo, the glass works of Sidon and Alexandria were famous in their times, and produced beautiful articles; which were cut, engraved, gilt, and stained of the most brilliant colors, in imitation of precious stones. The Romans employed glass for various purposes; and have left specimens in Herculaneum of window-glass, which must have been blown by methods analogous to the modern. The Phenician processes seem to have been learned by the Crusaders, and transferred to Venice in the 13th century, where they were long held secret, and formed a lucrative commercial monopoly. Soon after the middle of the 17th century, Colbert enriched France with the blown mirror glass manufacture.

Chance undoubtedly had a principal share in the invention of this curious fabrication, but there were circumstances in the most ancient arts likely to lead to it; such as the fusing and vitrifying heats required for the formation of pottery, and for the extraction of metals from their ores. Pliny ascribes the origin of glass to the following accident. A merchant-ship laden with natron being driven upon the coast at the mouth of the river Belus, in tempestuous weather, the crew were compelled to cook their victuals ashore; and having placed lumps of the natron upon the sand, as supports to the kettles, found to their surprise masses of transparent stone among the cinders. The sand of this small stream of Galilee, which runs from the foot of Mount Carmel, was in consequence supposed to possess a peculiar virtue for making glass, and continued for ages to be sought after and exported to distant countries for this purpose.

The researches of Berzelius having removed all doubts concerning the acid character of silica, the general composition of glass presents now no difficulty of conception. This substance consists of one or more salts, which are silicates with bases of potash, soda, lime, oxide of iron, alumina, or oxide of lead; in any of which compounds we can substitute one of these bases for another, provided that one alkaline base be left. Silica in its turn may be replaced by the boracic acid, without causing the glass to lose its principal characters.

Under the title glass are therefore comprehended various substances fusible at a high temperature, solid at ordinary temperatures, brilliant, generally more or less transparent, and always brittle. The following chemical distribution of glasses has been proposed.

1. Soluble glass; a simple silicate of potash or soda; or of both these alkalies.
2. Bohemian or crown glass; silicate of potash and lime.
3. Common window and mirror glass; silicate of soda and lime; sometimes also of potash.
4. Bottle glass; silicate of soda, lime, alumina, and iron.
5. Ordinary crystal glass; silicate of potash and lead.
6. Flint glass; silicate of potash and lead; richer in lead than the preceding.
7. Strass; silicate of potash and lead; still richer in lead.
8. Enamel; silicate and stannate or antimoniate of potash or soda and lead.

The glasses which contain several bases are liable to suffer different changes when they are melted or cooled slowly. The silica is divided among these bases, forming new compounds in definite proportions, which by crystallizing, separate from each other, so that the general mixture of the ingredients which constituted glass is destroyed. It becomes then very hard, fibrous, opaque, much less fusible, a better conductor of electricity and of heat; forming what Reaumur styled *devitrified* glass, and what is called after him, Reaumur's porcelain.

GLASS-MAKING, GENERAL PRINCIPLES OF. Glass may be defined in technical phraseology, to be a transparent homogeneous compound formed by the fusion of silica with oxides of the alkaline, earthy, or common metals. It is usually colorless, and then resembles rock crystal, but is occasionally stained by accident or design with colored metallic oxides. At common temperatures it is hard and brittle, in thick pieces; in thin plates or threads, flexible and elastic; sonorous when struck; fracture conchoidal, and of that peculiar lustre called vitreous; at a red heat, becoming soft, ductile, and plastic. Besides glass properly so called, other bodies are capable of entering into vitreous fusion, as phosphoric acid, boracic acid, arsenic acid; as also certain metallic oxides, as of lead and antimony, and several chlorides, some of which are denominated glasses. Impure and opaque vitriform masses are called slags; such are the productions of blast iron furnaces and many metallurgic operations.

Silica, formerly styled the earth of flints, which constitutes the basis of all commercial glass, is infusible by itself in the strongest fire of our furnaces; but its vitreous fusion is easily effected by a competent addition of potash or soda, either alone or mixed with lime or litharge. The silica, which may be regarded as belonging to the class of acids, combines at the heat of fusion with these bases into saline compounds; and hence glass may be viewed as a silicate of certain oxides, in which the acid and the bases exist in equivalent proportions. Were these proportions, or the quantities of the bases which silica requires for its saturation at the melting point, exactly ascertained, we might readily determine beforehand the best proportions of materials for the glass manufacture.

Glass-houses are commonly large conical buildings, from 60 to 100 feet high, and from 50 to 80 feet in diameter.

The furnace is in the middle, over a large vault, which is connected with it by means of an opening. This opening is covered with an iron grate, upon which the fire is made, and it is kept up by the draught of air from the vault.

The most important part, however, of the apparatus of the glass-house is the crucible, made from clay, found at Stourbridge. This is first pounded fine, then sifted, moistened, and worked into a thick dough. Sometimes old crucibles are used, which are broken into powder, and then mixed with a red clay. Some pots, for bottle and flint glass, are made 40 inches deep and wide. They are from 2 to 4 inches in thickness. They remain several days at a white heat, before they are placed in the furnace.

The basis of glass is *silica*. When flints or quartz are used, they are first reduced to powder by being heated red hot, and then plunged into cold water. This causes them to whiten and fall to pieces, after which they are ground and sifted. The second ingredient is potash or soda. The alkali used is more or less pure, according to the fineness of the glass to be made. Lime is often employed in small quantities; also borax.

Of the metallic oxides added in different cases, the deutoxide of lead is the most common. It renders flint glass more fusible, heavy, and tough, more easy to be ground and cut, and increases its brilliancy and refractive power.

A small quantity of black oxide of manganese renders the glass more transparent; too much gives a purple tinge, which, however, may be destroyed by a little charcoal or wood.

Arsenious acid (white arsenic), in small quantities, promotes the clearness of glass; too much of it gives the glass a milky whiteness. Its use in drinking-vessels is not free from danger, if the glass contains so much alkali that any part is soluble in acids.

The various materials are carefully washed, and, after the extraction of all the impurities, are conveyed to the furnace in pots made of tobacco-pipe clay. The produce of this process is called the *frit*, which is again melted in large pots or crucibles, till the whole mass becomes beautifully clear, and the dross rises to the top.

Blowing is the next process, which, in round glass, as phials, drinking-glasses, &c., is thus performed;—The workmen dip the end of long iron pipes, red hot, into the liquid glass, then roll it on a polished iron plate to give it an external even surface; they next blow down the iron pipe, till it enlarges the metal like a bladder, and, if necessary, roll it again on the iron plate, and proceed to form it into a globular form, or any other one required. The glass is then transferred from the blowing-pipe, by dipping the end of another iron rod into the liquid glass, which adheres to the heated rod, and with which the workman sticks it to the bottom of the vessel; then, with a pair of pincers, wetted with water, he touches the neck, which immediately cracks, and, on being slightly struck, separates at the end of the blowing-pipe, and becomes attached to the iron rod. The vessel is next carried up to the mouth of the furnace, to be heated and softened, that the operator may finish it. If the vessel require a handle, the operator forms it separately, and unites it while melting hot, forming it with pincers to the requisite shape and pattern.

Annealing is the removing of the glass, after it has been blown or cast, into a furnace, whose heat is not sufficiently intense to melt it; and gradually withdrawing the article from the hottest to a cooler part of the annealing chamber, till it is cold enough to be taken out for use. If cooled too suddenly, it is extremely brittle.

Coloring.—The different colored glasses owe their tints to the different metallic oxides mixed with the materials while in a state of fusion. In this manner are made those elegant *pastes*, which so faithfully imitate, and not unfrequently excel, in brilliancy, their originals, the gems of antiquity. The glass, however, for this purpose is preserved in a peculiar manner, and requires great nicety. It combines purity and durability.

Opaque glass is made by the addition of the oxide of tin, and produces that beautiful imitation of enamel which is so much admired. Dials for watches and clocks are thus made.

Bottle-glass is made of soap-boilers' waste and river sand, or sand and lime with clay and salt, mixed, evaporated, and fritted. *Common window-glass*, of 2 soap waste, 1 *kelp*, and 1 sand. *Super window-glass*, 25 sand, 12 sulphate of soda, or Glauber's salt, 4 carbonate of lime, or lime unburnt, and 1 of charcoal; or 2 purified sand, 3 strong kelp. *Plate*, or *sodaic glass*, is sand 100, sub-carbonate of soda 55, unslaked lime 9, nitre 4, and powdered glass 60. The product is three-fourths. *Flint*, or *litharge glass*, is 10 fine sand, 6 red lead, 8 pearlash, a half part oxide of manganese.

Grinding and *polishing* give plate-glass a fine lustre. The grinder takes it rough out of the hands of the caster, and, laying it upon a stone table, to which it is fixed with stucco, he lays another rough glass, half the size of the former, upon it. To the smaller glass a plank is fastened, by means of stucco, and to the whole a wheel, made of hard, light wood, about six inches in diameter, by the pulling of which from side to side, and from end to end, of the glass, a constant attrition is kept up; and, by allowing water and fine sand to pass between the plates, the whole is very finely polished; but, to give the finishing polish, powder of smalt is used. As the upper glass grows smoother, it is taken away, and a rougher one substituted in its stead; and so on till the work is done. Except in the very largest plates, the workmen polish their glass by means of a plank, having four wooden handles to move it; and to this plank a plate of glass is cemented, as above.

Various *ornamental forms* are given to the surface of glass vessels by metallic moulds. The mould is usually of copper, with the figure cut on its inside, and opens with hinges to permit the glass to be taken out. The mould is filled by a workman, who blows fluid glass into its top. The chilling of the glass, when it comes in contact with the mould, impairs its ductility, and prevents the impression of the figure from being sharp. Some moulds, however, are made in parts, which can be suddenly brought together on the inside and outside of the glass vessel, and produce specimens nearly equal to cut glass.

Cut glass, so called, is produced by grinding the surface with small wheels of stone, metal, or wood. The glass is held to the surface of the wheels. The first cutting is with wheels of stone; then with iron, covered with sharp sand or emery; and, finally, with brush wheels, covered with putty. A small stream of water is kept continually running on the glass, to prevent the friction from exciting too much heat.

Glass may be ground on any coarse grained stone, with sand, or emery and water. Flat pieces of glass may be divided in any shape, by making a notch with a file, and carrying a piece of hot charcoal before the line in which it is intended the fracture should proceed. The charcoal must be kept alive with the breath, and the progress humored by experience. Tubes, &c., are cut with a file all round, and then broken.

GLASS COLORING. Mr. G. Bontemps has shown that all the colors of the prismatic spectrum might be given to glass by the use of the oxide of iron in varying proportions and by the agency of different degrees of heat; and that all the colors are produced in their natural disposition in proportion as you increase the temperature. Similar phenomena were observed with the oxide of manganese. Manganese is employed to give a pink or purple tint to glass, and also to neutralize the slight green given by iron and carbon to glass in its manufacture. If the glass colored by manganese remains too long in the melting-pot or the annealing-kiln, the purple tint turns first to a light brownish red, then to a yellow, and afterwards to green. White glass in which a small proportion of manganese has been used is liable to become light yellow by exposure to luminous power. This oxide is also in certain window-glass disposed to turn pink or purple under the action of the sun's rays.

M. Bontemps has found that similar changes take place in the annealing oven. He has determined, by experiments made by him on polygonal lenses for M. Fresnel, that light is the agent producing the change mentioned; and the author expresses a doubt whether any change in the oxidization of the metal will explain the photogenic effect. A series of chromatic changes of a similar character were observed with the oxides of copper; the colors being in like manner regulated by the heat to which glass was exposed. It was found that silver, although with less intensity, exhibited the same phenomena; and gold, although usually employed for the purpose of imparting varieties of red, was found by varying degrees of heating at a high temperature and recasting several times to give a great many tints, varying from blue to pink, red, opaque yellow, and green. Charcoal in excess in a mixture of silico alkaline glass gives a yellow color, which is not so bright as the yellow from silver, and this yellow color may be turned to a dark red by a second fire. Mr. B. is disposed to refer these chromatic changes to some modifications of the composing particles rather than to any chemical changes in the materials employed.

GLAZIER'S PUTTY. Whiting and linseed drying oil, beaten together some time.

GLAZING EARTHENWARE AND PORCELAIN. In the bisquet state, earthenware and porcelain will adhere to the tongue, and imbibe moisture. The tendency of the earths to absorb water is the cause; and the ware in this state would not retain water and many other liquids. Hence, there is necessity for an artificial vitrified covering, whose components are so adapted to those of the body as to be equally affected with them by change of temperature, and preserve equality of expansion or contraction.

We have not yet discovered a body and glaze that will be complete ware by once baking. The components of the present bodies do not sufficiently conglomerate to remain unaffected by the moisture of the glaze, but the articles become soft, and either shrink, or alter their figure. The only probable suggestion towards this is:—Grind very well some of the flesh-colored feldspar from Montgomeryshire, precipitate whatever iron may be in the mineral, then add 8 per cent. of ground native carbonate of barytes, and 1 per cent. of cobalt blue calx; mix in water for *dip and glaze*, and fire only once. Feldspar is the glaze of Nankin porcelain.

The manufacturers have their particular *glazes*, for certain bodies. The several components are carefully proportioned, then ground to a pulpy state, almost impalpable between the thumb and finger; this is mixed with a certain quantity of water, and kept agitated to preserve uniform suspension. The dipper places nigh him a board covered with bisquet ware, and another with a number of small pegs or nails. He immerses (or dips) each article, with a suitable motion to cover the whole, then places it on the pegs to drain. The water is imbibed by the pores of the ware, and, to the thickness of writing paper, the components form a covering, which is vitrified by baking. From the pegs the vessel is placed in a sagger, and at a lower heat of the oven the whole glaze is fused.

The following are excellent glazes:

FOR PORCELAIN.—Pulverize well, and carefully fuse together, flint 20 parts, cullet 7, Cornish-stone 20, red lead 20, borax 20, subcarbonate of soda 7, nitrate of potash 8, oxide of tin 24, cobalt calx 1. *Or*,

Fuse together, flint glass 66 parts, red lead 15, arsenic 7, muriate of soda 5, nitrate of potash 6, cobalt calx 1. When well ground, mix with Cornish-stone 40 parts, frit (as above) 18 parts, flint 12 parts, and white lead 80; grind in the glaze mill, and use carefully.

Fuse together Cornish-stone 80 parts, soda 20; pulverize, and grind together, for use. The fritt 40 parts, flint 16, Cornish stone 24, and white lead 20.

Fuse together, cullet 85 parts, flint 10, white lead 2, arsenic 1, nitrate of potash 2; then grind together, fritt 30 parts, Cornish-stone 40, flint 25, boracic acid 5.

The feldspar glazes are subjoined for general purposes of utility. They are

most secretly preserved by their first employers, but it is well they be extensively known.

Fuse together, feldspar 66 parts, borate of soda 34; then grind, and mix with flint 95, nitrate of potash 5, ground for use.

Or, feldspar 60, borax 40, fused, and mixed with flint 50, potash 2.

Or, feldspar 90, carb. barytes 7, lime 2, magnesia 1; and mixed with flint 67, borax 30, and potash 8.

Or, feldspar 60, borax 24, nitre 6, salt 4, and potash 6, mixed with flint 60.

Raw glazes.—White lead 45, Cornish-stone 22, cullet 22, flint 8, borax 2, salt 1.

Or, white lead 51, Cornish-stone 25, cullet 11, flint 12, carb. potash 1.

Or, white lead 49, Cornish-stone 24, cullet 10, flint 14, borax 3.

Or, white lead 42, Cornish-stone 27, cullet 14, flint 11, bor. acid 6.

GLAZING IRON VESSELS. The iron vessels are cleaned perfectly in weak sulphuric acid, then washed well in soft cold water, and dipped into a thin paste made with quartz melted with borax, feldspar, and clay free from iron, reduced into an impalpable powder with sufficient water to make it into a thin paste. After the vessels are dipped in this paste, or the said paste laid on with a brush, they are powdered in the inside with a linen bag containing a very finely pulverized mixture of feldspar, carbonate of soda, borax, and a little oxide of tin. They are then left to dry for some time in a clean place, and then heated in an enamelling furnace. This coating is very white, and resists the action of heat, acids, and alkalies. The great defect in coating iron vessels, for cooking, or to be used and exposed to great changes of heat and cold, is the expansion and contraction of the metal, which soon scales off the glazial coverings.

GLASS PAINTING. In Painting, the method of staining glass in such a manner as to produce the effect of representing all the subjects whereof the art is susceptible. A French painter of Marseilles is said to have been the first who instructed the Italians in this art, during the pontificate of Julius II. It was, however, practised to a considerable extent by Lucas of Leyden, and Albert Durer. The different colors are prepared as follows: *Black* is composed of two-thirds of iron scales or flakes, and the other third of small glass beads, or a substance called *roccaglia* by the Italians. *White* is prepared from sand, or small white pebbles, calcined, pounded, and then ground finely; one fourth part of saltpetre is added, and the mixture is then again calcined and pulverized: when dyed, a little gypsum or plaster of Paris is added. *Yellow* is formed from leaf silver ground and mixed in a crucible with saltpetre or sulphur; then ground on a porphyry stone; and, lastly, ground over again with nine times the quantity of red ochre. *Red*, one of the most difficult of the colors to make, is prepared of litharge of silver and iron scales, gum Arabic, ferretta, glass beads, and bloodstone, in nearly equal quantities. Experience alone will command success in making this color. *Green* is formed from æs ustum one ounce, the same quantity of black lead, and four ounces of white lead, incorporated by the action of fire. When calcined a fourth part of saltpetre is added, and after a second calcination a sixth part more; after which a third coction is made before using it. *Azure*, *purple*, and *violet* are prepared in a similar manner to green, omitting the æs ustum, and in its stead using sulphur for azure, perigneux for purple, and both these drugs for violet. *Carnations* are compounded colors, are calcined, and mostly mixed with water, and must be finished part by part, and each with great dispatch, before the plaster dries, and there is little opportunity for blending. The lights cannot be heightened; but the shadows may, when they begin to dry, be a little strengthened. Promptitude and facility in execution are the great requisites for this method of painting.

GLAUBER'S SALT. Sulphate of soda, originally made by Glauber, in his process for obtaining muriatic acid, by distilling a mixture of common salt and sulphuric acid.

GLAUCOLITE. (Gr. γλαυκος, *blue.*) A mineral of a bluish green color, found near the lake Baikal, in Siberia; it is a silicate of alumina and lime.

GLUCINA. One of the primitive earths, originally discovered by Vauquelin, in the beryl and emerald. It may be extracted from either of these minerals, by treating their powder successively with potash, with water, and with muriatic acid. The solution by the latter, being evaporated to dryness, is to be digested with water, and filtered. On pouring carbonate of ammonia in excess into the liquid, we form soluble muriate of ammonia, with insoluble carbonates of lime, chrome, and iron, as also carbonate of glucina, which may be dissolved out from the rest by an excess of carbonate of ammonia. When the liquid is filtered anew, the glucina passes through, and may be precipitated in the state of a carbonate by boiling the liquid, which expels the excess of ammonia. By washing, drying, and calcining the carbonate, pure glucina is obtained. It is a white insipid powder, infusible in the heat of a smith's forge, insoluble in water, but soluble in caustic potash and soda; as also, especially when it is a hydrate, in carbonate of ammonia. It has a metallic base called glucinum, of which 100 parts combine with 45·252 of oxygen to form the earth. It is too rare to be susceptible of application in manufactures.

GLUE is the chemical substance gelatine in a dry state. The preparation and preservation of the skin and other animal matters employed in the manufacture of glue, constitute a peculiar branch of industry. Those who exercise it should study to prevent the fermentation of the substances, and to diminish the cost of carriage by depriving them of as much water as can conveniently be done. They may then be put in preparation by macerating them in milk of lime, renewed three or four times in the course of a fortnight or three weeks. This process is performed in large tanks of masonry. They are next taken out with all the adhering lime, and laid in a layer, 2 or 3 inches thick, to drain and dry, upon a sloping pavement, where they are turned over by prongs two or three times a day. The action of the lime dissolves the blood and certain soft parts, attacks the epidermis, and disposes the gelatinous matter to dissolve more readily. When the cleansed matters are dried, they may be packed in sacks or hogsheads, and transported to the glue manufactory at any distance. The principal substances of which glue is made are the parings of ox and other thick hides, which form the strongest article; the refuse of the leather-dresser; both afford from 45 to 55 per cent. of glue. The tendons, and many other offals of slaughter-houses, also afford materials, though of an inferior quality, for the purpose. The refuse of tanneries, such as the ears of oxen, calves, sheep, &c., are better articles; but parings of parchment, old gloves, and, in fact, animal skin, in every form, uncombined with tannin, may be made into glue.

These various matters are first rinsed, then drained, and afterwards boiled in large shallow copper vessels for some hours, during which they are well stirred.

The solution must be drawn off in successive portions; a method which fractions the products, or subdivides them into articles of various value, gradually decreasing from the first portion drawn off to the last. It has been ascertained by careful experiments that gelatine gets altered over the fire very soon after it is dissolved, and it ought therefore to be drawn off whenever it is sufficiently fluid and strong for forming a clear gelatinous mass on cooling, capable of being cut into moderately firm slices by the wire. This point is commonly determined by filling half an egg-shell with the liquor, and exposing it to the air to cool. The jelly ought to get very consistent in the course of a few minutes; if not so, the boiling must be persisted in a little longer. When this term is attained, the fire is smothered up, and the contents of the boiler are left to settle for a quarter of an hour. The stop-cock being partially turned, all the thin gelatinous liquor is run off into a deep boiler, immersed in a warm water bath, so that it may continue hot and fluid for several hours. At the end of this time, the supernatant clear liquid is to be drawn off into congealing boxes, in which the solution as it cools into a jelly takes the shape of the space. It is then exposed to the air, or a stove heat, to dry, and receives a gloss by being dipped in water and brushed. It is finally dried, and rendered fit for packing.

GLUTEN was first extracted by Beccaria from wheat flour, and was long regarded as a proximate principle of plants, till Einhof, Taddei, and Berzelius, succeeded in showing that it may be resolved by means of alcohol into three different substances, one of which resembles closely animal albumine, and has been called *Zymome*, or vegetable albumine; another has been called *Gliadine*; and a third, *Mucine*. The mode of separating gluten from the other constituents of wheat flour has been described towards the end of the article Bread.

Gluten, when dried in the air or a stove, diminishes greatly in size, becomes hard, brittle, glistening, and of a deep yellow color. It is insoluble in ether, in fat, and essential oils, and nearly so in water. Alcohol and acetic acid cause gluten to swell and make a sort of milky solution. Dilute acids and alkaline leys dissolve gluten. Its ultimate constituents are not determined, but azote is one of them, and accordingly when moist gluten is left to ferment, it exhales the smell of old cheese.

GLYCERINE is a sweet substance which may be extracted from fatty substances. If we take equal parts of olive oil and finely-ground litharge, put them into a basin with a little water, set this on a sand bath moderately heated, and stir the mixture constantly, with the occasional addition of hot water to replace what is lost by evaporation, we shall obtain in a short time a soap or plaster of lead. After having added more water to this, we remove the vessel from the fire, decant the liquor, filter it, pass sulphureted hydrogen through it to separate the lead, then filter afresh, and concentrate the liquor as much as is possible without burning upon the sand bath. What remains must be finally evaporated within the receiver of the air-pump. Glycerine thus prepared is a transparent liquid, without color and smell, and of a sirupy consistence. It has a very sweet taste. Its specific gravity is 1·27 at the temperature of 60°. When thrown upon burning coals, it takes fire and burns like an oil. Water combines with it in almost all proportions; alcohol dissolves it readily; nitric acid converts it into oxalic acid; and according to Vogel, sulphuric acid transforms it into sugar, in the same way as it does starch. Ferment or yeast does not affect it in any degree.

Its constituents are, carbon, 40; hydrogen, 9; oxygen, 51; in 100.

GNEISS is the name of one of the great mountain formations, being reckoned the oldest of the stratified rocks. It is composed of the same substances as granite, viz.: quartz, mica, and feldspar. In gneiss, however, they are not in granular crystals, but in scales, so as to give the mass a slaty structure. It abounds in metallic treasures.

GOLD. This metal is distinguished by its splendid yellow color; its great density = 19·8, compared to water 1·0; its fusibility at the 32d degree of Wedgewood's pyrometer; its pre-eminent ductility and malleability, whence it can be beat into leaves only one 282,000th of an inch thick; and its insolubility in any acid menstruum, except the mixture of muriatic and nitric acids, styled by the alchymists *aqua regia*, because gold was deemed by them to be the king of metals.

Gold is found only in the metallic state, sometimes crystallized in the cube, and its derivative forms. It occurs also in threads of various size, twisted and interlaced into a chain of minute octahedral crystals; as also in spangles or roundish grains, which, when of a certain magnitude, are called *pepitas*. The small grains are not fragments broken from a greater mass; but they show by their flattened ovoid shape, and their rounded outline, that this is their original state. The spec. grav. of native gold varies from 13·3 to 17·7. Humboldt states that the largest *pepita* known was one found in Peru, weighing about 12 kilogrammes (26¼ lbs. avoird.); but masses have been quoted in the province of Quito which weighed nearly four times as much.

It is scattered over the whole globe in primary geological districts; in the mountains of Wicklow in Ireland; in Leadhills, Scotland, and parts of Wales. In France, in the Valley of Oyseens, there is a vein of gold in quartz. Its auriferous rivers are numerous. The Rhone, near Geneva, the Rhine, near Strasbourg, the Salat, Garonne, and the Herrault. The gold mines of Piedmont are still worked. It is worked at Salzbourg, in Germany, and also in Hungary and Transylvania. The Asiatic Ural chain contains many gold mines; Africa possesses large auriferous deposits, chiefly alluvial. In South America, Brazil, Chili, Peru, and Colombia, furnish productive quantities of gold. It is found in Canada, Maine, Virginia, North and South Carolina, and California, in this continent. Along the Sierra Nevada, in this latter state, are found the chief sites of the gold diffused through the quartz mass. Along the Yuba, Trinity, San Joachim, Sacramento, and San Francisco rivers, numerous rich placers have been found in the beds of the streams. There seems to be no limit to the extent of the quantity of gold diffused through the granitic rocks of this district, from which by attrition the streams have derived their gold. At Trinity Bluffs, the gold scales are found mixed with Basaltic sand, which so envelops and protects the gold that it is difficult to separate and purify the metal.

Auriferous sands require little treatment to separate the gold. The sands are washed on a rocking table, and afterwards in wooden bowls by hand. Amalgamation is employed to carry off from the sand the lighter particles of gold; much of the California gold is obtained in this way. In some places the sand is so heavy as not to allow the particles of gold to be separated, nor can acids be used, as lime and iron are present; solution of chlorine from chloride of lime has been found to separate the gold effectually. In South Carolina the plan adopted is this:—The ore is crushed by huge rotating iron rollers, during which a gentle fall of water carries the metal, as fast as it is pulverized, through a small aperture into a narrow trough, across which, at intervals, is a deposit of mercury. The trough is slightly inclined, by which means the sand passes out freely while the gold adheres to the quicksilver. At the close of the day this mercury, with the gold attached, is all taken out, and by a simple process called "panning," the metals are neatly separated. The mercury is bottled for re-use, and the gold is burned to eradicate the few particles of mercury which still adhere to it.

The other ores are metallic sulphurets, as those of copper, silver, arsenic, and iron. The following is an outline of the treatment of these:—The stony ores are first ground in the stamping mill, and then washed in hand-basins, or on wooden tables.

The auriferous sulphurets are much more common, but much poorer than the former ores; some contain only one 200,000th part of gold, and yet they may be worked with advantage, when treated with skill and economy.

The gold of these ores is separated by two different processes; namely, by fusion and amalgamation.

The auriferous metallic sulphurets are first roasted; then melted into *mattes*, which are roasted anew; next fused with lead, whence an auriferous lead is obtained, which may be refined by the process of cupellation.

When the gold ores are very rich, they are melted directly with lead, without preliminary calcination or fusion. These processes are, however, little practised, because they are less economical and certain than amalgamation, especially when the gold ores are very poor.

If these ores consist of copper pyrites, and if their treatment has been pushed to the point of obtaining auriferous rose copper, or even black copper including gold, the precious metal cannot be separated by the process of liquation, because the gold, having more affinity for copper than for lead, can be but partially run off by the latter metal. For these reasons the process of amalgamation is far preferable.

This process being the same for silver, its description is reserved for that metal. The rich ores in which the native gold is apparent, and merely disseminated in a stony gangue, are directly triturated with quicksilver, without any preparatory operation. As to the poor ores, in which the gold seems lost amid a great mass of iron, sulphuret of copper, &c., they are subjected to a roasting before being amalgamated. This process seems requisite to lay bare the gold enveloped in the sulphurets. The quicksilver with which the ore is now ground, seizes the whole of its gold, in however small quantity this metal may be present.

The gold procured by the refining process with lead, is free from copper and lead, but it may contain iron, tin, or silver. It cannot be separated from iron and tin without great difficulty and expense, if the proportion of gold be too small to admit of the employment of muriatic acid.

By cupellation with lead, gold may be deprived of any antimony united with it.

Tin gives gold a remarkable hardness and brittleness; a piece of gold, exposed for some time over a bath of red-hot tin, becomes brittle. The same thing happens more readily over antimony, from the volatility of this metal. A 2,000th part of antimony, bismuth, or lead, destroys the ductility of gold. The tin may be got rid of by throwing some corrosive sublimate or nitre into a crucible containing the melted alloy. By the first agent, perchloride of tin is volatalized; by the second, *stannate* of potash forms, which is carried off in the resulting alkaline scoriæ.

Gold treated by the process of amalgamation, contains commonly nothing but a little silver. This silver is dissolved out by nitric acid, which leaves the gold untouched; but to make this *parting* with success and economy on the great scale, several precautions must be observed.

If the gold do not contain fully two-thirds of its weight of silver, this metal, being thoroughly enveloped by the gold, is partially screened from the action of the acid. Whenever, therefore, it is known by a trial on a small scale, that the silver is much below this proportion, we must bring the alloy of gold and silver to that standard by adding the requisite quantity of the latter metal. This process is called quartation.

This alloy is then granulated or laminated; and from twice to thrice its weight of sulphuric or nitric acid is to be boiled upon it; and when it is judged that the solution has been pushed as far as possible by this first acid, it is decanted, and new acid is poured on. Lastly, after having washed the gold, some sulphuric acid is to be boiled over it, which carries off a two or three thousandth part of silver, which nitric acid alone could not dissolve. Thus perfectly pure gold is obtained.

The *alloys* of gold have been examined in detail by Mr. Hatchett. Of these the most important is that used for the gold coin of England, commonly called *standard gold*, which consists of eleven parts of pure gold and one of copper; it is extremely ductile and malleable, but harder than pure gold, and, therefore, better calculated to resist the wear and tear of circulation. The specific gravity of this alloy is 17·157: 20 lbs. troy of it are coined into 934 sovereigns and one half sovereign; 1 lb. troy, therefore, produces 46 29-40 sovereigns; the same weight was formerly coined into 44½ guineas. The color of this alloy is deeper yellow than that of pure gold, and verges upon orange: it frequently happens that a part of the alloy of gold coin is silver, hence the pale color of some sovereigns as compared with others. The United States gold contains an alloy of one-tenth of copper. Among the metals which destroy the color and malleability of gold, none is so remarkable as lead. It appears from Mr. Hatchett's experiments, that when lead forms about one 2000th part of the alloy, it is too brittle for rolling, and that the fumes of lead destroy the good qualities of gold. The chemical equivalent of gold is probably about 200, and that of the protoxide 208, and of the protochloride 236. The peroxide is a compound of one proportional of gold and three of oxygen, and the perchloride contains three proportionals of chlorine. When ether is agitated with solution of chloride of gold, it takes up the metal, and forms a yellow ethereal solution of gold; when polished steel instruments are dipped into this solution, and immediately washed in water, and wiped with a piece of soft leather, they become beautifully gilt with a very thin film of gold. *See* GILDING.

For the separation of gold in a spongy form, Dr. C. Jackson, of Boston, adopts an economical plan. After separating the gold and silver by aqua regia, the solution containing gold and copper is evaporated to a small bulk, and the excess of nitric acid driven of. A little oxalic acid is then added, and a solution of carbonate of potass sufficient to take up nearly all the gold as aurite of potass, is gradually added. Then an excess of oxalic acid is added, and the whole boiled. The gold is immediately precipitated in the form of sponge: this is a suitable form for the jeweller and dentist.

Gold, Artificial: The following is Hemsdorf's proportions for imitation gold, which not only resembles gold in color, but also in specific gravity and ductility; it consists of 16 parts of platinum, 7 parts of copper and 1 of zinc, put in a crucible, covered with charcoal powder, and melted into a mass.

Gold, Amalgam: Place a gold leaf in the palm of the hand, and pour upon it a globule of mercury. The latter will be seen to absorb, or combine with the gold; forming a more or less fluid and yellow amalgam, according to the proportion of the two metals. This amalgam is used in water gilding. The affinity of mercury for gold and silver is so strong, that those who are foolish enough to clean their watch cases with mercury, or one of its salts, will find them irretrievably spoiled; the same holds good with plated articles cleaned by a vile composition, sold about the streets for this purpose, made of the nitrate of mercury, ground up with whitening.

Water gilders adopt the following plan to make amalgam: They put 2 drachms of mercury into a crucible, and heat it until vapor is seen to issue from it; now throw into the crucible 1 drachm of gold or silver, and stir them with an iron rod. When the gold or silver is found to be fused, or incorporated with the mercury, the amalgam is poured into cold water; when cold, pour off the water, and collect the amalgam, which will be of about the consistence of soft butter. This after having been bruised in a mortar, or shaken in a strong phial, with repeated portions of salt and water, till the water ceases to be fouled by it, is fit for use, and may be kept for any length of time without injury in a stopped phial. It is essential in this manufacture, that the mercury should be extremely pure, as the least admixture of lead, tin, or metal would materially injure the gilding for which it is used.

GOLD-BEATING. The malleability and extreme divisibility of gold are the foundation of the art of *gold-beating.* In consequence of the wonderful extension which the gold-beater is enabled to give to this precious metal, it is employed for ornamental purposes to an extent which, from its comparative scarcity, would otherwise be impossible. Thus, it is estimated that an equestrian statue, of the natural size, may be gilded with a piece of gold not exceeding in value $8. The gilding of the dome of the *Hotel des Invalids* at Paris cost but £8500. And in India, where it is common to gild towers, bridges, gates, and colossal idols, it is known to be attended with still less expense. In *gold-beating*, the gold used is as pure as possible, and the operation is commenced with masses weighing about two oz. These are beaten into plates six or eight inches long, by three quarters of an inch wide. They are then passed between steel rollers, till they become as thin as paper. Each one of these is now cut into 150 pieces, and forged on an anvil till it is about an inch square, after which they are well annealed. Each of the squares in this state weighs 6·4 grs., and in thickness is equal to 1-766th of an inch. The 150 plates of gold, thus produced from one mass, are interlaid with pieces of very fine vellum, about four inches square, and about 20 vellum leaves are placed on the outside; the whole is then put into a case of parchment, over which is drawn another similar case, so that the packet is kept close and tight on all sides. It is now laid on a smooth block of marble, and the workman begins the beating with a round-faced hammer, of 16 lbs; the packet is turned, occasionally, upside down, and beaten with strong strokes, till the gold is extended nearly to an equality with the vellum leaves. The packet is then taken to pieces, and each leaf of gold is divided into four with a steel knife. The 600 pieces, thus produced, are interlaid with pieces of animal membrane, from the intestines of the ox, of the same dimension, and in the same manner as the vellum. The beating is continued, but with a lighter hammer, about 12 lbs., till the gold is brought to the same dimensions as the interposed membrane. It is now again divided into four, by means of a piece of cane, cut to an edge. The 2400 leaves hence resulting are parted into three packets, with interposed membrane as before, and beaten with the *finishing*, or *gold hammer*. The packets are now taken to pieces, and the gold leaves, by means of a cane instrument and the breath, are laid flat on a cushion of leather, and cut, one by one, to an even square, by a cane frame; they are lastly laid in books of 25 leaves each, the paper of which is previously smoothed, and rubbed with red bole, to prevent them from adhering.

Gold Wire is, in fact, only silver wire gilt, and is prepared in the following manner: A solid cylinder of fine silver, weighing about 20 lbs., is covered with thick leaves of gold, which are made to adhere inseparably to it, by means of the burnisher: successive laminæ are thus applied, till the quantity of gold amounts to 100 grs. for every lb. troy of silver. This gilt silver rod is then drawn successively through holes made in a strong steel plate, till it is reduced to the size of a thick quill, care being taken to anneal it accurately after each operation. The succeeding process is similar to the former, except that a mixed metal, somewhat softer than steel, is employed for the drawing-plates, in order to prevent the gilding from being stripped off; and no further annealing is requisite after, if it is brought to be as slender as a crow-quill. When the wire is spun as thin as is necessary, it is wound on a hollow copper bobbin, and carefully annealed by a very gentle heat; finally, it is passed through a flatting mill, and the process is complete.

Gold Thread.—The gold thread commonly used in embroidery consists of threads of yellow silk, covered by flattened gilt wire, closely wound upon them by machinery.

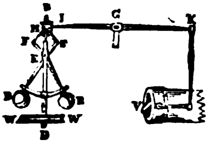
Crystallization of Gold. A small glass-stoppered vial, containing a solution of gold in a mixture of nitric and muriatic acids, had stood neglected for a considerable time (perhaps four or five years) in a cupboard. Upon accidentally examining it, it was found a portion of the acid had escaped, and the gold crystallized. This effect had probably been promoted by a flaw in the vial, which extended through the neck, and a little way down its length. The stopper in consequence must have been slightly loosened, and thus allowed more space for the formation of a thin dendritic crystallization of the gold. This was further continued down the inner surface of the vial, and was there sufficiently thick to admit the impression of minute, but distinct crystallization facets. A small crystallized lump of gold lay at the bottom of the vial; but supposed to have been originally attached to the rest, and merely by its weight, as has since observed to be the case in another portion. Around the stopper, and along the flaw, there was a saline concretion, which tasted like sal-ammoniac, and as ammonia was kept in the same cupboard, it had probably united with the muriatic acid as it exuded. On examining some other metallic solutions, it was found that a similar separation of the metal had taken place in a vial containing a solution of platina, and in another, containing a solution of palladium. In both these cases, a thin, interrupted, and dentritic lamina of metal might be seen between the stopper and the neck; but the crystallization had proceeded no further. On unstopping the vial containing the platina, the lamina (as might have been expected) immediately disappeared in the form of a slight muddy film. These facts, if multiplied, may, perhaps, serve to throw some light upon the mode in which the dentritic laminæ of native gold, silver, &c., are formed in rocks.

Gold (Chloride of). Great difficulty has hitherto occurred in preparing the chloride of gold, of the yellow and red colors, perfectly soluble in water, and without suffering reduction. The following processes are recommended for this purpose:—

1st. In order to prepare the yellow salt of gold, take aqua regia prepared with three parts of hydro-chloric acid, one part of nitric acid, and one of distilled water. Then put one part of pure gold into a porcelain capsule with a plate of glass, and heat it in a salt water bath, the heat being continued till red vapors cease; the cover is then to be removed, and if the gold is not entirely dissolved, some aqua regia is to be added to it, the capsule being again covered, the heat is to be continued till vapor ceases to appear; the glass plate must then be removed and replaced by folds of blotting paper, the heat being continued in the bath, until a glass rod, upon being immersed in the capsule, becomes covered with yellow solid chloride of gold.

The capsule is then to be removed from the salt water bath and the chloride of gold soon crystallizes in small prismatic crystals, of a fine yellow color, with an orange tint. The chloride thus obtained is perfectly soluble in water without reduction; it is successfully employed in Daguerreotype and other operations.

The red chloride of gold (ter-chloride) is prepared in the same manner, except that the aqua regia employed is prepared with two parts of hydro-chloric, and one part of nitric acid. The operation is commenced by acting upon gold with excess of aqua regia on a sand bath, the salt water bath not being used until the gold is entirely dissolved; the remainder of the operation is conducted in the same manner as that for the yellow chloride.



GOVERNOR. A contrivance for regulating the speed of machinery, which has long been in use in mill-work, but has of late years attracted more attention by its adaptation to the steam-engine. It consists of two heavy balls B B, attached to the extremities of two rods B F, B F, which play upon a joint at E, passing through a mortise in the vertical shaft D D. These are united by joints at F to the short rods F H, which again are connected by joints at H to a ring, which slides on the shaft D D. A horizontal wheel, W, is attached to D D, having a groove to receive a rope or strap on its rim, by means of which the motion is communicated to D D from a corresponding wheel on some shaft of the machinery to be regulated. It is evident, from the disposition of the rods, that if the balls B B are by any means raised or drawn asunder, the extremities F F of the rods turning on the pivot E will also be separated, and their distance from the axes increased. This will draw the rods F H in the same direction, and cause the ring or collar H to descend. This ring is connected with the end I of a lever, whose fulcrum is at G, and whose other extremity K is connected by some means with the part of the machine which supplies the power. Suppose now the velocity from any cause to undergo a sudden increase; by reason of the increased centrifugal force arising from the whirling motion, the balls B B will recede from the shaft D D, and raise the extremity K of the lever. On the other hand, if the velocity is diminished, the centrifugal force of the balls will be diminished, and they will fall by their own weight nearer the axes, and cause the end K of the lever to descend. When the governor is applied to a steam-engine, the rod K I communicates with a flat circular valve V, placed in the principal steam-pipe, and so arranged that when K is elevated as far as the divergence of the balls will allow, the opening of the pipe will be closed by the valve V, and the passage of steam entirely stopped. On the other hand, when the balls subside to their lowest position, the valve will be entirely open. Thus, when the velocity is increased, the supply of steam is checked; and when it is diminished, the supply of steam is immediately increased; by which means a uniform proper velocity of the machinery is maintained.

When the governor is applied to a water wheel, the lever is made to act on the shuttle through which the water flows, and thereby controls its quantity. When applied to a windmill, it regulates the sailcloth so as to diminish the efficacy of the power upon the arms as the force of the wind increases, or *vice versâ*.

GRAFTING. The operation of affixing one portion of a plant to another, in such a manner as that vital union may take place between them. A graft consists of two parts; the stock or stem, which is a rooted plant, fixed in the ground, and the scion, a detached portion of another plant, to be affixed to it. The operation of grafting can only be performed within certain limits.

In general, all the species of one genus may be grafted on one another reciprocally; but this is not universally the case, because the apple cannot be grafted on the pear, at least not for any useful purpose. In general, it may be presumed that all the species of a natural order, or at least of a tribe, may be grafted on one another; but this does not hold good universally. The reverse of this doctrine, however, that the species belonging to different natural orders cannot be grafted on one another holds almost universally true; and therefore a safe practical conclusion is, that in choosing a stock, the nearer in affinity the species to which that stock belongs is to the scion, the more certain will be the success.

Grafting is one of the most important operations in horticulture, as affording the most eligible means of multiplying and perpetuating all our best varieties of fruit-trees, and many kinds of trees and shrubs not so conveniently propagated by other means. Varieties of fruits are originally procured by selection from plants raised from seed, but they can only be perpetuated by some mode which continues the individual; and though this may be done by cuttings and layers, yet by far the most eligible mode is by grafting, as it produces stronger plants in a shorter time than any other methods.

Grafting is performed in a great many different ways, but the most eligible for ordinary purposes is what is commonly called spliced grafting or whip grafting. In executing this mode, both the scion and the stock are pared down in a slanting direction; afterward applied together, and made fast with strands of bast matting, in the same manner as two pieces of rod are spliced together to form a whip handle. To insure success, it is essentially necessary that the alburnum or inner bark of the scion should coincide accurately with the inner bark of the stock, because the vital union is effected by the sap of the stock rising up through the soft wood of the scion. After the scion is tied to the stock, the graft is said to be made; and it only remains to cover the part tied with a mass of tempered clay, or any convenient composition that will exclude the air. The season for performing the operation is, for all deciduous trees and shrubs, the spring, immediately before the movement of the sap. The spring is also the most favorable season for evergreens; but the sap in this class of plants being more in motion during winter than that of deciduous plants, grafting, if thought necessary, might be performed at that season.

Grafting by approach, or inarching, is a mode of grafting, in which, to make sure of success, the scion is not separated from the parent plant till it has become united with the stock. For this purpose, the stock and the plant containing the scion must be growing close together; and the scion being drawn to one side, and made to approach the stock, is spliced to it by cutting off a portion of its bark and wood, and a similar portion of the bark and wood of the stock, applying the one to the other so that their alburnums may join, and then making both fast by matting, and excluding the air by clay, grafting wax, or moss. When the scion has effected a vital union with the stock, its lower extremity is cut through, so as to separate it from the parent plant, and it now becomes an independent graft. In this way trees of difficult propagation may be propagated with certainty; while if any of the other modes of propagation, whether by cuttings or grafting, were adopted, a proportion of the cuttings or scions would, in all probability, be lost.

Grafting herbaceous plants differs in nothing from grafting such as are of a woody nature, excepting that the operation is performed when both stock and scion are in a state of vigorous growth. Grafting herbaceous plants is but little practised in England, and on the Continent chiefly as a matter of amusement. The only useful purpose to which it has hitherto been applied, is that of grafting the finer kinds of dahlias on tubers of the more common and vigorous growing sorts. In the Paris gardens the tomato is sometimes grafted on the potato, the cauliflower on the borecole, and one gourd on another, as matter of curiosity.

Grafting the herbaceous shoots of woody plants—the greffe herbace of the French—is scarcely known among English gardeners; but it has been extensively employed by French nurserymen, and even in some of the royal forests of France. The scions are formed of the points of growing shoots; and the stocks are also the points of growing shoots cut or broken over an inch or two below the point, where the shoot is as brittle as asparagus. The operation is performed in the cleft manner: that is, by cutting the lower end of the scion in the form of a wedge, and inserting it in a cleft or slit made down the middle of the stock. The finer kinds of azalias, pines, and firs are propagated in this way in the French nurseries, and thousands of *Pinus laricio* have been so grafted on *Pinus sylvestres* in the forest of Fontainebleau. At Hopetoun House, near Edinburgh, this mode of grafting has been successfully practised with *Abies Smithiana*, the stock being the common spruce fir.

GRANITE is considered as the foundation rock of the globe, or that upon which all secondary rocks repose. From its great relative depth, it is not often met with, except in Alpine situations, where it presents the appearance of having broken through the more superficial strata of the earth, the beds of other rocks in the vicinity rising towards it at increasing angles of elevation as they approach it. It is composed of three minerals, viz., quartz, feldspar, and mica, which are more or less perfectly crystallized and closely united together.

The three constituents of granite are as under, taking their mean:

	Feldspar.	Quartz.	Mica.
Silica.......	64	96	47
Alumina......	19	2	22
Lime.......	2	2	
Potash	13	0	14·5
Iron. (oxide)	1	0	15
Mang. (do.) .	0	0	1·75

Granite has been divided into several sub-species, or varieties; of these, the following are the most important:—*Common granite*, in which the three ordinary constituents above-mentioned occur in nearly equal proportions; the feldspar may be white, red, or gray. *Porphyritic granite*, in which large crystals of feldspar are disseminated through a common granite, whose ingredients are fine grained. *Graphic granite*, which consists of feldspar in broad laminæ, penetrated perpendicularly with long imperfect crystals of quartz, whose transverse angular sections bear some resemblance to certain letters, especially to those of Oriental languages. *Sienite* or *sienitic granite*, in which hornblende, either wholly or in part, supplies the place of mica. *Talcky* or *chloritic granite* (the *protogine* of the French), in which talc or chlorite takes the place of the mica. *Feldspathic granite*, in which feldspar is the principal ingredient.

The aspect of granitic mountains is extremely diverse, depending, in part, upon the nature of its stratification, and the degree of disintegration it has undergone. Where the beds are nearly horizontal, or where the granite, from the preponderance of feldspar, is soft and disintegrating, the summits are rounded and heavy. Where hard and soft granite are intermixed in the same mountain, the softer granite is disintegrated, and falls away, leaving the harder blocks and masses piled in confusion upon each other, like an immense mass of ruins. Where it is hard, and the beds are nearly vertical, it forms lofty pyramidal peaks or *aiguilles*, like the Aiguille de Duc and others, in the neighborhood of Mont Blanc.

Granite forms some of the most lofty of the mountain-chains of the eastern continent. In Europe, the central part of the principal mountain-ranges is of this rock—as in Scandinavia, the Alps, the Pyrenees, and the Carpathian mountains. In Asia, granite forms a considerable part of the Uralian and Altaic ranges of mountains; and it appears, also, to compose the principal mountains that have been examined in Africa; whereas, in the western hemisphere, it has never been observed rising to such great elevations, or composing such extensive chains. It is, nevertheless, very abundantly distributed over the northern parts of the American continent, as in Labrador, the Canadas, and the New England States. In New Hampshire, it is the predominating rock of the White Mountains, in which it attains the elevation of more than 6000 feet. In the Andes, it has been observed at the height of 11,000, but is here generally covered by an immense mass of matter, ejected by ancient and recent eruptions.

Granite very frequently forms veins

shooting up into the superincumbent rocks, which seems to indicate that it has existed below in a state of fusion, the heat of which has softened and parted the upper rocks, and forced up the granite, in a melted state, into these fissures.

Granite abounds in crystallized earthy minerals; and these occur, for the most part, in those masses of it existing in veins. Of these minerals, beryl, garnet, and tourmaline, are the most abundant. It is not rich in metallic ores, though it contains the principal mines of tin, as well as small quantities of copper, iron, tungsten, bismuth, silver, columbium, and molybdenum.

Granite supplies durable materials for architecture and for decoration. It varies much in hardness, as well as in color; accordingly, there is room for much care and taste in its selection.

GRANULATION; the method of dividing metallic substances into grains or small particles. This is done either by pouring the melted metal into water, or by agitating it in a box until the moment of coagulation, at which instant it becomes converted into a powder.

GRAPES. The method of training vines at Fontainebleau, where the famous grapes are produced that supply the Paris markets, consists in allowing the plants very little room to grow either with their branches or their roots, and in keeping the latter very near the surface of the ground; each vine is only allowed to occupy a space of about six feet, so that the walls are supplied by a multitude of plants.

The error in growing grapes in Britain consists in training them into elevations. They ripen best when trained near the ground, in open air. The heat of hothouses is an exception. Vineyards, in France, resemble plantations of gooseberry-bushes, with the bunches close to the soil, the heat of which ripens them.

Grape Wine. Take water 4¼ galls., grapes 5 galls., crushed and soaked in the water 7 days, sugar 17½ lbs. The cask in which it was made held exactly 6¾ galls., and produced 34 bottles of wine clear. A bottle kept 10 years proved very good.

To preserve Grapes. Take a well-bound cask, from which the head is to be removed, and place at the bottom a good layer of bran. On this place a layer of grapes, then bran and grapes alternately until the cask is full. Put on the head, which is to be cemented, and the grapes will keep for a year. When used, in order to restore their freshness, fresh cut the stalk of each bunch, and place it in wine, as flowers are placed in water.

GRAPE-SHOT. In artillery, a quantity of small shot put into a canvas bag, and corded together in the form of a cylinder, the diameter of which is adapted to the piece of ordnance from which it is intended to be discharged. It is now superseded by *canister-shot.*

GRAPHOMETER. A mathematical instrument used in land surveying; otherwise called a *semicircle.*

GRAPHITE. The substance improperly called *black lead,* of which pencils are made. It is a peculiar form of mineral carbon with a trace of iron. The finest is found only at Borrodale in Cumberland. Coarse varieties are not uncommon. It occurs very abundantly throughout the United States.

GRAPNEL. A small anchor for a boat.

GRAPLING IRONS. Small grapnels with four flukes for securing ships together in action.

GRASS, is the union, in spring, of 11 species of natural grasses in one pasture; in summer of 11 other species, and in autumn of 8 others, florin, yarrow, and couch. Certain weeds and flowers, also, mingle in small quantities, as buttercups, burnet, sorrel, dock, &c. Some species prevail in particular soils, but the most general in all. is cocksfoot, meadow-fescue, crested dog's-tail, hand-fescue, sweet-scented vernal, rye, (grasses,) and upright brome. The meadow fox-tail and oat-grasses occasionally abound.

GRAY DYE. The gray dyes, in their numerous shades, are merely various tints of black, in a more or less diluted state, from the deepest to the lightest hue.

The dyeing materials are essentially the tannic and gallic acid of galls or other astringents, along with the sulphate or acetate of iron, and occasionally wine-stone. Ash-gray is given for 30 pounds of woollen stuff, by one pound of gall-nuts, ¼ pound of wine-stone (crude tartar), and 2¼ pounds of sulphate of iron. The galls and the wine-stone being boiled with from 70 to 80 pounds of water, the stuff is to be turned through the decoction at a boiling heat for half an hour, then taken out, when the bath being refreshed with cold water, the copperas is to be added, and, as soon as it is dissolved, the stuff is to be put in and fully dyed.

Pearl-gray is produced by passing the stuff first through a decoction of sumach and logwood (two pounds of the former to one of the latter), afterwards through a dilute solution of sulphate or acetate of iron; and finishing it in a weak bath of weld containing a little alum. *Mouse-gray* is obtained, when with the same proportions as for ash-gray, a small quantity of alum is introduced.

For several other shades, as tawny-gray, iron-gray, and slate-gray, the stuff must receive a previous blue ground by dipping it in the indigo vat; then it is passed first through a boiling bath of sumach with galls, and lastly through the same bath at a lower temperature after it has received the proper quantity of solution of iron.

For dyeing silk gray, fustet, logwood, sumach, and elder-tree bark, are employed instead of galls. Archil and annotto are frequently used to soften and beautify the tint.

GRAVITY. (*See* SPECIFIC GRAVITY.)

GREASE. *Anti*-attrition for axles:

1st. One part of fine black lead, ground perfectly smooth, with four parts lard. Some recipes add a little camphor.

2d. BOOTH'S AXLE GREASE, (expired patent.) Dissolve ½ lb. of common soda in 1 gallon of water; add 3 lbs. of tallow, and 6 lbs. palm oil (or 10 lbs. palm oil only), heat them together to 200 or 210° Fahr.; mix and keep the mixture constantly stirred till the composition is cooled down to 60 or 70°. A thinner composition is made with ½ lb. of soda, a gallon of water, a gallon of rape oil, and ¼ lb. of tallow or palm oil.

GREEN PAINTS. Green, which is so common a color in the vegetable kingdom, is very rare in the mineral. There is only one metal, copper, which affords in its combinations the various shades of green in general use. The other metals capable of producing this color are, chromium in its protoxyde, nickel in its hydrated oxyde, as well as its salts, the seleniate, arseniate, and sulphate; and titanium in its prussiate.

Green pigments are prepared also by the mixture of yellows and blues; as, for example, the green of Rinman and of Gellert, obtained by the mixture of cobalt blue, and flowers of zinc; that of Barth, made with yellow lake, Prussian blue, and clay; but these paints seldom appear in the market, because the greens are generally extemporaneous preparations of the artists.

Mountain green consists of the hydrate, oxyde, or carbonate of copper, either factitious, or as found in nature.

Bremen or Brunswick green is a mixture of carbonate of copper with chalk or lime, and sometimes a little magnesia or ammonia. It is improved by an admixture of white lead. It may be prepared by adding ammonia to a mixed solution of sulphate of copper and alum.

Frise green is prepared with sulphate of copper and sal ammoniac.

Mittis green is an arseniate of copper; made by mixing a solution of acetate or sulphate of copper with arsenite of potash. It is in fact Scheel's green.

Sap green is the inspissated juice of buckthorn berries. These are allowed to ferment for 8 days in a tub, then put in a press, adding a little alum to the juice, and concentrated by gentle evaporation. It is lastly put up in pigs' bladders, where it becomes dry and hard.

Schweinfurt green; see SCHWEINFURT.

Verona green is merely a variety of the mineral called green earth.

GREEN VITRIOL is sulphate of iron in green crystals.

GREEN, PRUSSIAN, is the sediment of the two first processes for making *Prussian blue*, before the muriatic acid is added; or it may be made by pouring oxymuriatic acid upon fresh precipitated Prussian blue.

GREYWACKE, a German word of three syllables, which imports a formation of distinct pieces of quartz, hard slate, and feldspar, combined in a bed of clay slate. But when the pieces are granulated in the clay state, it is then called greywacke slate. It contains early shells though a transition rock; also transition limestone and trap, with many ores and veins. Since its formation there must have been at least 12 revolutions of the perihelion.

GUANO or HUANO. A substance first noticed by Humboldt and sent by him from Peru to France, where it was examined by Vauquelin. It is the excrement of sea-birds inhabiting the coast of South Seas. Besides excrement, it is made up of the remains of penguins, albatrosses, and gannetts, booby birds and seals. It is found at Chincha and Payta, in Peru, and in Chili. It also abounds in Ichaboe and a few smaller islands off the West coast of Africa. Peruvian guano is found on the islands of the Pacific, near the coast of Peru, and some of the headlands on the adjacent shores between lat. 18° and 21° South. It is here deposited to the depth of 50 and 60 feet. Within this district rain seldom falls, and there is little waste either of the substance or quality of these accumulations from the lapse of time or the action of elements. The water fowl, which resort to this coast and the vicinal island, subsist principally on fish, and their fæces are, of course, richer in nitrogen than any species of the feathered tribes, excepting such as are exclusively carnivorous.

The Chincha islands, which afford the best Peruvian guano, are three in number, and lie in one line from north to south, about half a mile apart. Each island is from five to six miles in circumference, and consists of granite covered with guano in some places to a height of 200 feet, in successive horizontal strata, each stratum being from 3 to 10 inches thick, and varying in color from light to dark brown. No earthly matter whatever is mixed with this vast mass of excrement. At Mr. Bland's visit to these islands in 1842, he observed a perpendicular surface of upward of 100 feet of perfectly uniform aspect from top to bottom. In some parts of these islands, however, the deposit does not exceed 3 or 4 feet in thickness. In several places, where the surface of the guano is 100 feet or more above the level of the sea, it is strewed here and there with masses of granite, like those from the Alpine mountains, which are met with on the slopes of the Jura chain. These seem to indicate an ancient formation for the guano, and terraqueous convulsions since that period. No such granite masses are found imbedded within the guano, but only skeletons of birds.

The good preservation of the Chincha guano is to be ascribed to the absence of rain; which rarely, if ever, falls between the latitude of 14° south, where these islands lie, about 10 miles from the main land, and the latitude of Paquica, on the island of Bolivia, in 21° S. L. By far the soundest cargoes of guano which have been analyzed have come from Chincha and Bolivia. Beyond these limits of latitude, where rain falls in greater or less abundance, the guano is of less value—and what has been imported from Chili has been found very far advanced in decay—most of the ammonia and azotized animal substances having been decomposed by moisture, and dissipated in the air (by the *eremacausis* of Liebig), leaving phosphate of lime largely to predominate along with effete organic matter. The range of the American coast from which the guano is taken must therefore be well considered; and should not extend much beyond the Chincha islands as the northern limit, and Paquica, in Bolivia, as the southern.

Peruvian guano is of a light brown color, resembling yellow loam, and is the best guano yet discovered, or than any other manure yet known; besides nitrogen, which it contains so abundantly, it contains a large amount of phosphoric acid united with lime and magnesia, and as both of these substances are so necessary to the cultivated crops, it is the reason why this substance is *the manure.* The following remarks of Dr. Ure explain this point more fully:—

The admirable researches of Professor Liebig have demonstrated that AZOTE, the indispensable element of the nourishment of plants, and especially of wheat and others abounding in gluten (an azotized product), must be presented to them in the state of *ammonia*, yet not altogether ammonia in the pure or saline form, for, as such, it is too readily evaporated or washed away; but in the dormant, or as one may say, in the *potential* condition in contradistinction from the *actual.* Genuine Peruvian and Bolivian guanos, like those which have been minutely analyzed, surpass very far all other species of manure, whether natural or artificial, in the quantity of *potential* ammonia, and, therefore, in the permanency of their action upon the roots of plants, while, in consequence of the ample store of *actual* ammonia which they contain ready formed, they are qualified to give immediate vigor to vegetation. Urate of ammonia constitutes a considerable portion of the azotized organic matter in well-preserved guano; it is nearly insoluble in water, not at all volatile, and is capable of yielding to the soil, by its slow decomposition, nearly one-third of its weight of ammonia. No other manure can rival this animal saline compound. One of the said samples of guano afforded me no less than 17 per cent. of potential ammonia, besides 4½ per cent. of the actual or ready formed; others from 7 to 8 per cent. of ammonia in each of these states respectively. These guanos which were examined are the mere excrement of birds, and are quite free from the sand, earth, clay, and common salt, reported in the analyses of some guanos, and one of which (sand) to the amount of 30 per cent. has been found in a sample of guano from Chile.

The Peruvian guano, moreover, contains from 10 to 25 per cent. of phosphate of lime, the same substance as bone-earth, but elaborated by the birds into a pulpy consistence, which, while it continues insoluble in water, has been thereby rendered more readily absorbable and digestible (so to speak) by the roots of plants. There is therefore no doubt, that by the judicious application of these genuine guanos, mixed with twice or thrice their weight of a marly or calcareous soil, to convert their phosphate of ammonia into phosphate of lime and carbonate of ammonia, as also to dilute all their ammoniacal compounds—such crops will be produced, even on sterile lands, as the farmer has never raised upon the most improved soil by the best ordinary manure. To the West India planter, guano will prove the greatest boon, since it condenses in a portable and inoffensive shape the means of restoring fertility to his exhausted cane-fields, a benefit it has long conferred on the poorest districts of Peru.

Messrs. A. Gibbs, of London and Liverpool, have a monopoly of the sale of Peruvian guano. This, perhaps, is not to be regretted, as what comes direct from them is genuine, and otherwise it is impossible to procure an unadulterated article, so great is the temptation and extensive the use of the article. A sample lately imported into New-York by Messrs. A. B. Allen, Water-st., N. Y., and analyzed by the editor, afforded by chemical examination in 100 parts,

Water	7 33
Organic matter and salts of ammonia as urate oxalate and sulphate	69·79
Phosphates of lime and magnesia and ammonia phosphate of magnesia	17·60
Lime	·60
Sulphuric acid	3·
Alkaline salts, chloride of sodium, and traces of potass	·48
Sand	1·20
	100·00

This guano was capable of yielding 12¼ per cent. of ammonia.

The following analysis of a good sample of Peruvian guano made by the late Mr. Fownes, England, affords a good idea of what is the constitution of a superior article in 100 parts:

Azotized animal matter, including urate of ammonia and other ammoniacal salts, together, capable of affording from 8 to 16 per cent. of ammonia by slow decomposition in the soil	50·
Water	11·
Phosphate of lime	25·
" of ammonia, oxalate of ammonia, phosphate of magnesia, together, yielding from 5 to 9 parts of ammonia	18·
Silica	1·
	100·

From the foregoing analysis its valuable character is evident. This is sustained by the astonishing and generally profitable results which follow its application, and has rendered it, though of recent introduction, one of the most popular manures in this country and Europe. It has been known and appreciated by the Peruvians, from time immemorial; and by its liberal use, combined with irrigation, they have for ages produced the most abundant crops of maize and wheat. It was not used agriculturally in Europe until 1840; in England at present 400,000 tons per year are used.

African or *Ichaboe* and *Patagonian* guano have been brought into this country to a limited extent. They have been used with advantage, but are by no means equal to the Peruvian variety. Those guanos have been accumulated in damp climates, and have hence undergone decomposition, so that most, if not all, the urate of ammonia is broken up into oxalate of ammonia—a salt far less valuable in agriculture: even this is dissipated and washed away by the rains, so that the proportion of ammoniacal salts falls often in this variety below 20 per cent., leaving the phosphates in a corresponding excess, so that it more resembles bones in composition.

Guano was first introduced into the States in 1825, when it was used in gardens, and forgotten: after its use in England it was again re-imported. Its application here was but slow in increase, yet it has advanced, and the demand for this year will probably be 25,000 tons. Its value cannot be over-estimated, as it is suitable for almost all crops and soils, but is perhaps best adapted for sandy loams. From 2 to 5 cwt. is a proper dressing. It is better to compost it with five times its bulk of loam, vegetable mould, or with charcoal or gypsum. Lime or ashes must be avoided carefully, as the ammonia is thus driven off. It should be kept dry and under cover, as that which smells strongest is losing its ammonia. It is usually spread broadcast on meadows and grain, or placed with the seeds in the hill: it develops both leaf and ear wonderfully, and hence is as suitable for grain as for green crops; it ought to be used *only* in autumn or in spring in the south. The sun's heat is too great for summer application, the loss of ammonia being very great.

GUDGEONS are the ends of axles, on which they work and rest. In water-wheels they ought to be strong enough, but not so large as to increase friction unnecessarily. The proportions of wrought iron and cast iron are as 8 inches to 8¼ or 8 to 9½.

To determine their diameter, extract the cube-root of the weight of the water-wheel, in hundred weights, and the root is the inches for the diameter in cast-iron; but if wrought-iron, it may be as 14 to 9 less. If it is a wooden axle, multiply the diameter in feet by the width in feet, and add half the square of the diameter: then the cube-root of this sum is the diameter of the fit gudgeon in inches. A gudgeon contains in cwts. the cube of its diameter in inches.

GUM. A vegetable product, distinguished by solubility in water, and insolubility in alcohol; it is tasteless and inodorous. Gum-arabic, which is the produce of the *Acacia vera*, may be taken as a sample of the purest form of gum. It is imported from Barbary and Morocco. Its specific gravity is 1·45. Its solution is viscid, and is termed *mucilage*. Gum is used as a demulcent in medicine, and for giving a gloss to linens, silks, &c. It consists of carbon 41·4, oxygen 52·09, hydrogen 5·51; or, in other terms, of 41·4 charcoal and 58·6 water.

Guerin has analyzed several varieties of gum. *Arabin*, which constitutes the greater portion of gum-arabic, is composed of

Carbon	43·81
Oxygen	49·85
Hydrogen	6·20
Azote	·14
	100·00

Gum-arabic is found to consist of

Arabin	79·40
Water	17·60
Ashes	3·00
	100·00

Messrs. Gay-Lussac and Thenard found its composition to be:

Arabin	84·16
Water	13·43
Ashes	2·41
	100·00

The difference of water found depended upon the different methods of analysis.

The dried root of the *blue-bell* contains mucilage, very similar to gum-arabic.

Gum senegal is less soluble than gum-arabic, and deeper in color.

GUM-RESIN. An exudation from many trees, composed of a mixture of gum and resin, or of a substance intermediate between the two.

GUN. Under this general term most of the species of fire-arms are included, the pistol and mortar being almost the only exceptions. Great guns, or cannon, began to be used as military engines about the middle of the 14th century; but small guns, or muskets, appear to have been introduced nearly two centuries later, namely, 1521. They were first used by the Spanish infantry at the siege of Rhege. Muskets were at first of a very clumsy construction, being so heavy that they could not be levelled and fired from the shoulder; accordingly the soldier was provided with a rest, which it was necessary to carry along with him and plant in the ground in order to support the weapon before it could be used. The gun was generally fired with a match; sometimes by means of sparks generated by the revolution of a notched wheel of steel, placed directly above the pan containing the priming. Muskets with rests were employed so lately as the civil wars in the time of Charles I.; afterwards a lighter matchlock musket came into use; and about the beginning of the last century the troops throughout Europe were armed with firelocks.

Small guns were invented by Swartz, a German, about 1378; brought into use by the Venetians, 1382. Cannon were first used at the battle of Cressy, 1346; first used in England at the siege of Berwick, 1405; first cast in England, 1544; used in shipping by the Venetians, 1539; before they were only used to batter walls. Mohammed, at the siege of Constantinople, employed some of the largest guns ever made use of before or since. One of his cannon was of such enormous size as to require 70 yoke of oxen to draw it, and 2000 men to man it. It discharged a ball of the weight of 300 lbs. The report was heard to a great distance, and the country shaken to the distance of 40 furlongs.

The barrel forms the essential part of the gun; and the first requisite to a good barrel is toughness in the material of which it is made, for safety in using it depends mainly on this quality. The best iron for the formation of musket barrels is that which has been much worn, and toughened by the loss of its fiery particles; and, accordingly, old horse stub-nails are much in request for this purpose, and sold at a high price to the barrel-forgers. Formerly the best gun-barrels were made in Spain; and their superiority was attributed to the excellency of the iron made use of, which consisted almost exclusively of stub-nails, and the old shoes of horses and mules: but the barrels now made in this country are not inferior to those of any country in the world. The method of making the barrel is this: the iron is first formed into a thin flexible bar, something like a cooper's hoop, and when heated is plied or twisted round a mandril, much in the same manner as a ribbon of leather is turned round the handle of a whip. For the best barrels the breadth of the bar does not exceed half an inch; and it is turned round the mandril in such a manner that the edges are brought close together, but do not overlap. In this position it is wedded by horizontal strokes with the hammer. But in common guns a broader bar is employed; and its edges, which are placed so as to overlap considerably, are welded down on each other. The Damascus barrels, prized for their beauty, though inferior in strength, are composed of iron and steel in certain proportions laid crossways, and hammered together the whole length of the barrel. After the barrel has been forged, the inside is rendered smooth and perfectly cylindrical by boring it with a bit, or rather bits of different sizes used in succession. In rifles a certain number of parallel grooves, either straight or slightly twisted, are cut in the inside of the barrel, of equal depth and fineness, and through its whole length. The exterior is smoothed by turning it on a lathe.

Mr. Aaron Rose, of Worcester, England, has just enrolled his description of a new method of manufacturing twisted gun barrels, which is thus described:—An iron or steel rod, or a mixture of both, of sufficient length and thickness to form a gun or pistol barrel, is wound into a compact coil, and then placed in an anvil having a semi-circular groove, where it is submitted to the action of the tilt hammer. The coil is then submitted to a welding heat in an air furnace, then hammered and rolled, a stream of water being used in both cases to wash away the scale.

The tilt hammer has a groove on its face corresponding with the anvil to act upon the coil, before the welding.

Mr. Vandenberg, a Flemish gentleman, has invented a new gun which can make six and eight charges per minute, carrying the distance of 2000 feet; the ball weighs about one ounce and a quarter, and the powder is one-twelfth the weight of the ball. An ordinary gun requires three times more powder, the ball does not weigh half an ounce. The new gun is loaded from the breech. The shape of the ball is round. At Utica, N. Y., the new rifle of Mr. Milo M. Cass discharged 24 balls in two minutes and 30 seconds; then loading with 26 cartridges in 4 minutes, and discharged 24 in 2 minutes and 30 seconds,—thus loading once and firing 48 shots in 9 minutes. The shooting was very accurate, considering the rapidity, and the performance of the gun gave great satisfaction to those present. The barrel of the gun was so little heated after the first 24 discharges, that it was immediately loaded and again fired the same number of times.

The *Air-Gun* is a machine in which highly-compressed air is substituted for gunpowder to expel the ball, which will be projected forward with greater or less velocity, according to the state of condensation and the weight of the body projected. The effect will, therefore, be similar to that of a gun charged with gunpowder, for inflamed gunpowder is nothing more than air very greatly condensed, so that the two forces are exactly similar. There is this important consideration to be attended to, namely, that the velocities with which balls are impelled are directly proportional to the square root of the forces; so that if the air in an air-gun be condensed only ten times, the velocity will be equal to one-tenth of that arising from gunpowder; if condensed twenty times, the velocity would be one-seventh that of gunpowder, and so on. Air-guns, however, project their balls with a much greater velocity than that assigned above; and for this reason, as the reservoir or magazine of condensed air is commonly very large in proportion to the tube which contains the ball, its density is very little altered by passing through that narrow tube, and consequently the ball is urged all the way by nearly the same force as at the first instant; whereas the elastic fluid arising from inflamed gunpowder is but very small indeed in proportion to the tube or barrel of the gun, and therefore, by dilating into a comparatively large space, as it urges the ball along the barrel, its force is proportionally weakened, and it always acts less and less on the ball in the tube.

An air-gun recently invented by Mr. Shaw, of Glassop, England, is one of much simplicity of construction. It has not the effective force of gunpowder, but it will enable a sportsman to amuse himself at but little expense, and will do execution, too, at considerable distance from the mark. The air that projects the bullet is condensed by a piston, which draws out a strong India rubber spring, which, when it is set free, suddenly draws up the piston, condensing the air in the air chamber, and impelling it against the bullet to discharge it with considerable velocity and power.

GUNPOWDER is explosive nitre brought into intimate contact with inflammable sulphur and charcoal. 75 of the nitre, 16 of charcoal, and 9 of sulphur, pounded as paste with wooden mortars, fixed in a wheel for 12 hours. It is granulated by being forced through a sieve, and glazed by agitation in a cask. The gas formed by an explosion is 2 volumes of nitrogen to 1 carbonic acid.

Dr. Ure has analysed various samples of gunpowder, and the following are the results of his investigations:—

Waltham Abbey, nitre 74·5, charcoal 14·4, sulphur 10·0, water 1·1.

Hall, Dartford, nitre 76·2, charcoal 14·0, sulphur 9·0, water 0·5.

Pigou and Wilks, nitre 77·4, charcoal 13·5, sulphur 8·5, water 0·6.

Curtis and Harvey, nitre 76·7, charcoal 12·5, sulphur 9·0, water 1·1.

Battle gunpowder, nitre 77·0, charcoal 13·5, sulphur 8·0, water 0·8.

Charcoal, sulphur, and nitre, being ready for manufacturing into gunpowder. 1st. They are separately ground to a fine powder, which is passed through proper silk sieves or bolting machines. 2d. They are mixed together in the proper proportions. 3d. The composition is then sent to the gunpowder mill, which consists of two edge-stones of a calcareous kind, turning by means of a horizontal shaft on a bed-stone of the same nature; incapable of affording sparks by collision with steel. On this bed-stone the composition is spread, and moistened with as small a quantity of water as will, in conjunction with the weight of the revolving stones, bring it into a proper body of *cake*, but by no means to a pasty state. The line of contact of the rolling edge-stone is constantly preceded by a hard copper scraper, which goes round with the wheel, regularly collecting the caking-mass, and bringing it into the track of the stone.

The materials for gunpowder are ground by a wheel revolving in a trough. They are then moistened and put into boxes with holes in the bottoms. The boxes are placed in a circular frame suspended by cords, and briskly agitated by a crank, when the paste passes through the holes as corns of powder. These are afterwards polished by being revolved in a barrel, dried by vessels of steam, and packed for sale.

Gunpowder to be good should be quick, strong, free from impurity, and not liable to absorb moisture. The general method of trying the purity is by burning it on clean white paper: two or three small heaps are made near each other, and one of them is fired; if the smoke rises perpendicularly, and there be no feculent matter left on the paper, nor the other heaps fired, it is considered that the ingredients were of a good quality, and well compounded. If the other heaps are fired, the paper burnt, or a dirty residuum left, it may be supposed that the nitre was impure, or that the charcoal was not completely pulverized.

M. Angendre, Assayer at the Mint of Constantinople, has addressed a communication to the Academy of Sciences at Paris, describing the discovery of a new explosive powder, having for its base the prussiate of potash. The composition is (by weight) crystallized dry yellow prussiate of potash one part, dry white sugar one part, chlorate of potash one part. These three substances are reduced separately in a mortar to fine powder, and then intimately mixed by hand. In operating on any quantity, the mixture is moistened with a very little water, and beaten in a bronze mortar with a wooden pestle. It is not necessary that the mixture should be as intimate as in the case of ordinary gunpowder,—a quarter of an hour will suffice to mix it. It is then grained in the ordinary manner, and dried in the air. The discoverer, M. Angendre, considers that this powder is equal in strength to three times its weight of the common kind. It is easily made, and the substances of which it is composed have a fixed and determined composition. It is not injured either in dry or damp air, but it is not suitable for small fire-arms, only for those of cast-iron, and it will answer a good purpose in blasting. The reason why it is not good for any fire-arms of steel is owing to the chlorate of potash, which oxidizes steel with great rapidity. Some of our civil engineers may find this powder invaluable for blasting, as they can make it themselves, it being equally as effective when in a state of powder as when grained. No other powder must be allowed to mix with it, for in rumming the bore for a blast, the friction of the particles of the old powder will be ready to ignite the new kind.

GUNTER'S CHAIN, so called from its reputed inventor, is the chain commonly used for measuring land. It is 66 feet or 4 poles in length, and is divided into 100 links, each of which is joined to the adjacent one by three rings; and the length of each link, including the connecting rings, is 7·92 inches. The advantage of this measure consists in the facility which it affords to numerical calculation. The English acre contains 4840 square yards; and Gunter's chain being 22 yards in length, the square of which is 484, it follows that a *square chain* is exactly the tenth part of an acre. A square chain again contains 10,000 square links, so that 100,000 square links are equal to an acre; consequently, the contents of a field being cast up in square links, it is only necessary to divide by 100,000, or to cut off the last five figures, to obtain the contents expressed in acres.

GUNTER'S LINE. A logarithmic line engraved on scales, sectors, &c., serving to perform the multiplication and division of numbers instrumentally, as a table of logarithms does arithmetically. The numbers are usually drawn on two separate rulers sliding against each other. In rough calculation this line affords considerable facilities.

GUNTER'S QUADRANT. A quadrant of a peculiar kind adapted to the problems of finding the hour of the day, the sun's azimuth, and other common problems of the sphere.

GUN COTTON was first announced by Professor Schonbein, and shown by him to the Natural History Society of Basle in 1846. Shortly after this Bæltzer, Otto, and Morel, discovered similar explosive compounds, all of which may fairly be traced to Pelouse and Braccaurd's discovery of Xyloidine. It has been looked on as identical with the latter, but not correctly, for gun cotton dissolves in acetic acid, while xyloidine does not. Schonbein made it originally by dipping cotton in nitric acid, sp. gr. 1·49, which after immersion for ten minutes it was rinsed in a large quantity of cold water, to free it from any adhering acid; and then carefully dried. Dr. Ellet, Professor of Chemistry in University of South Carolina, adopted as an improvement the use of sulphuric acid, with the view of keeping the nitric acid concentrated. Dr. Taylor, of London, adopted a similar plan; nitre was afterwards added to the mixed acids. In order to obtain a good gun cotton it is necessary

1st. To steep purified cotton in a mixture of equal parts of nitric and sulphuric acids.

2d. The duration of immersion is not important: the best samples have been ten minutes steeped.

3d. A mixture may be used in which cotton has been previously immersed, reviving it if necessary.

4th. The cotton must not be above the level of the liquid.

5th. It must be dried slowly, and not exposed, especially when damp, to a temperature exceeding 100°.

6th. By washing in water saturated with nitre or chlorate of potass its power is a little increased, but it is not worth the additional expense.

Burned on the hand it causes no sensible pain, leaves no stain, and produces no smoke; dipped in water and pressed, and afterwards dried between two leaves of blotting paper, it preserves its fulminating properties. It explodes on being heated to 350°, or on bringing a red hot body in contact with it: a dry piece of the cotton laid upon gunpowder may be exploded without igniting the powder. This is due to the rapidity of the explosion. Mr. E. F. Teschemacher and Mr. R. Forrett have found gun cotton to consist uniformly of nitric acid and liquin, in the proportion of 60 of the former to 40 of the latter. Properly exploded in a narrow glass tube so as to collect the gaseous product, 52·33 grains of the cotton were found to give 100 c. i. of gas, of which the composition was remarkable, consisting of

Carbonic acid........	14·286, or 2 vols.
Cyanogen	7·143, or 1 vol.
Nitric oxide	35·715, or 5 vols.
Carbonic oxide	35·915, or 5 vols.
Nitrogen	7·143, or 1 vol.

Besides which a sublimate of oxalic acid and a quantity of water was formed in the combustion.

Exposed to a dry heat, between 200° and 300°, it became brown, and lost its explosive property. Steaming it, seems to increase its power.

Examined under the microscope, there is no difference visible between cotton so prepared and that unacted on by acid. Under the action of polarized light there is, however, a marked difference. The fibres of ordinary cotton are then brilliantly illuminated on a dark colored ground, while the gun cotton is dark and colorless, and invisible at every half turn of the prism.

In practice, it has not fulfilled all that was originally predicted of it; it is unfit for gunnery and fire-arms of any kind, but is admirably adapted for mining and blasting.

The advantages of its use are: its cleanliness, the rapid combustion, and non residuum; the absence of any bad smell; its lightness; the possibility of handling it without danger at a distance from the fire; the absence of dust, and its indisputable force, which is triple that of gunpowder of equal weight. The disadvantages are: bulk, increased inflammability, the disadvantage of evolving vapor during its explosion; it *wets* the guns and cannon just as gunpowder *fouls* them.

Gun cotton dissolved in ether forms a good varnish for covering wounds, or giving a thin film to cover any surface, and is a powerful deoxidizer, reducing salts of silver and a few other metals very rapidly.

GUTTA PERCHA, or *Gutta Tuban*. The Malay name for the concrete juice of a large forest tree: one of the Sapoteæ—a native of Borneo, Malacca, and the neighboring countries. It is chiefly brought from Singapore: it was used by the natives as a substitute for horn and wood, to make handles for knives and choppers. The juice is obtained by cutting down the tree, and allowing the juice to exude from the cut end. This is a most wasteful proceeding, as the number of trees must shortly be so limited as to destroy the supply of the article. Mr. Brooke, of Borneo, says the tree is often six feet in diameter at Sarawak, and is believed to be plentiful all over Borneo, and probably at the thousand islands that cluster to the south of the Straits of Singapore. Its frequency is proved by the circumstance that several hundred tons of the Gutta Percha have been annually exported from Singapore since 1842, when the substance first came into notice. There is reason, however, to fear that the supply must shortly decrease, and the price be raised, from the wasteful mode in which the natives collect it, often sacrificing a noble tree, of from fifty to one hundred years growth, for the sake of twenty or thirty pounds of gum, which is the largest quantity any one trunk ever affords. The juice might, in all likelihood, be obtained from the *Percha*, as from other trees, by tapping, and thus procuring a smaller portion for several successive years; but this process is too slow for the Malayans, and is also less likely to be adopted because the forests are common property. The people fell the tree, strip off its bark, and collect its milky juice in a trough formed of the hollow stem of the plantain leaf, when, being exposed to the air, it soon coagulates.

As it comes to market, it is a dirty white, pinkish, solid, opaque, having but little smell, and insoluble in water; it has a silky, fibrous texture, especially when drawn out. It feels smooth and greasy between the fingers. Below 50° it is hard, tough, and partially flexible, when thin like horn; between 50° and 70°, it is elastic, and more flexible, yet still tough and stiff, between 140° and 160°, it becomes quite soft and plastic, and loses its tenacity. In this state pieces of it may be joined, all that is necessary being to press them together, when they form a perfect joint. By cutting it up in fragments, and boiling in hot water, most of the impurities may be removed. When thus purified by cooling, it passes into a solid mass; when softened by either hot water or simple dry heat, it may be molded into any shape, or pressed into a pattern: as it cools, it gradually recovers its toughness and rigidity. In consequence of this it forms perfect casts of coins, medals, &c., which, if carefully made, have all the sharpness of sulphur without its brittleness. When hot, it is easily cut with the knife or saw, but when cold it is difficult to cut it, without wetting the tool with cold water. It is lighter than water, and floats on it: the spec. gravity being when pure ·9791. In its chemical relations it closely resembles caoutchouc, and is isomeric with it: it differs, however, in some physical properties. By destructive distillation it yields similar products, affording a clear limpid oil of a mixed composition between 360° and 390°. It is insoluble in alcohol and water, dissolves partially in oil of turpentine, ether, and perfectly in cold naphtha, benzole, sulphuret of carbon, and caoutchicine. Of these the benzole is the fittest; when dissolved in it by the aid of gentle heat, and then poured out on a glass plate to evaporate the benzole, the gutta percha is left behind in the form of a white film or skin. In this way very thin sheets of this substance is obtained. Souberain has made an ultimate analysis of it, which yielded to him carbon 87·8, hydrogen 12·2. Mr. Crane believes the crude article to be composed of two substances: 1st, the pure white gutta; and 2d, a brown coloring material. Benzole separates them.

Dr. Montgomerie suggests, among the less immediately obvious uses to which gutta percha is applicable, that of making raised type for the blind, and embossed maps for the same unfortunate beings; it takes a clear, sharp impression, and is also tough and durable; he thinks it would likewise be found serviceable in stopping decayed teeth.

G. Hancock, Esq., has taken out a patent for improving the manufacture of gutta percha. He suggests several methods of purifying the substance, which generally comes here much mixed with extraneous matter. It may be dissolved by heat and strained, or passed through a screw press, or melted by the addition of rectified oil of turpentine; and, after filtering through flannel or felt, the solvent may be evaporated. In every case the gutta percha should form a residuum of the consistency of dough or putty—this plastic state being gained by the maintenance of a suitable temperature during the above process.

Mr. Hancock would combine gutta percha with caoutchouc, and a substance called *gintawan* (we have no clue to what this gintawan may be), in order to form an elastic material impervious to water; varying the proportions according to the greater or less degree of hardness or elasticity required for making elastic bands—a compound is used where 50 parts of gutta percha are combined with 24 of gintawan, 20 of caoutchouc, and 6 of orpiment. From a mixture of these, Mr. Hancock also prepares a light, porous, and spongy material, suited for stuffing or forming the seats of chairs, cushions, mattresses, saddles, &c.; likewise, springs of clocks, clasps, belts, garters, and strings. Wherever the requisite is flexibility and elasticity, then the quantity of gutta percha should be diminished, and increased where firmness is wanted. By prolonging the process much hardness may be acquired, and moulds and balls of gutta percha will bear turning in the lathe, like wood or ivory. The material is also applicable to useful and ornamental purposes, as picture frames, door handles, walking sticks, chessmen, handles of swords, and knives, buttons, combs, flutes, &c., &c. By the admixture of sulphuric acid, or of a tenth or larger part of vegetable wax or tallow, any degree of solubility, pliancy, and softness, may be acquired; or the composition may be used as varnish to cover other materials, concealing any odor, and imparting a surface impervious to water. In printing silks and cottons it is useful, as it amalgamates readily with colors. The applications of gutta percha are endless: it makes good tubes for conveying water or gases; speaking tubes, and hose; drinking vessels, pitchers, basins, and other domestic articles. An extensive use is as soles for shoes, which are fastened to the clean and rasped leather sole by a fluid varnish made of the gutta dissolved in coal tar. A solution of it forms a good varnish for wires or cordage, or any substance which it may be desirable to protect or insulate. It is sulphurized occasionally, and sometimes combined with caoutchouc. At the American Gutta Percha Company, having their factory in Brooklyn, N. Y., the various modifications and articles of which this substance is susceptible of being applied to, is interestingly demonstrated.

Gutta percha is of the most powerful negative electrics, and may be used for insulating positive surfaces, or for developing quantities in place of the glass cylinder. A thin sheet of this substance wrapped round a bottle or wooden cylinder, and turned by hand, gives a copious supply of the fluid for experiment.

Previous to 1844, the very name of gutta percha was unknown to European commerce. In that year two cwt. of it was shipped, experimentally, from Singapore. In the first four and a half years of the trade, 21,598 piculs of gutta percha valued at $274,190, were shipped at Singapore, the whole of which were sent to England, with the exception of 15 piculs to Mauritius, 470 to the Continent of Europe, and 922 to the United States. But this rapid growth of the new trade conveys only a faint idea of the commotion it created among the native inhabitants of the Indian Archipelago. The jungles of Johore were the scenes of the earliest gatherings, and they were soon ransacked, in every direction, by parties of Malays and Chinese, while the indigenous population gave themselves up to the search with a unanimity and zeal only to be equalled by that which made railway jobbers of every man, woman, and child in England, about the same time. The knowledge of the article stirring the avidity of gatherers, gradually spread from Singapore northward as far as Penang, southward along the east coast of Sumatra to Java, eastward to Borneo, where it was found at Brune, Sarawak and Pontianak on the west coast at Keti, and Passe on the east.

GYPSUM. *Sulphate of lime, alabaster, plaster of Paris.* Plaster. This substance is found in three geological situations in the crust of the earth: 1st, among the early secondary rocks; 2d, in the new red sandstone formations, and above the chalk in the tertiary beds. The gypsum of England is found in the new red sandstone, that of France in the tertiary beds, and that of this country is chiefly in the secondary formation. In the State of New-York are the best developed beds of gypsum as yet explored in this country, where they are found in the beds known to correspond with the *upper silurian strata* of English geologists. It extends over the central and western portions of the State in a belt extending from east to west, where it thickens as it advances until it reaches Ontario county, where its greatest purity and development appears to exist. It is quarried extensively in Cayuga, Yates, and Ontario county. The purest varieties consist of the elements of the crystallized selenite or alabaster, viz.:

Sulphuric acid	40
Lime	28
Water	18
	In 86 parts.

But the rock gypsum is never so pure; it contains aluminous or argillaceous clay, and variable quantities of carbonate of lime and magnesia, soluble salts, and silica. The Editor of this work having occasion to examine the soils and minerals of Seneca county, N. Y., found the composition of the rock gypsum to be as follows in 100 parts.

Water	6·60
Carbonate of lime	17·40
Carbonate of magnesia	9·80
Insoluble silicates and sand	39·60
Salts of alkalies soluble in water.	·40
Sulphate of lime	26·20
	100·00

The gypsum of Ontario county is purer, and is fit for application in the arts, which the above is not. These beds of gypsum occur chiefly in isolated masses, appearing as if they had crystallized out of a plastic moist clay, and are generally surrounded by a gypseous marl made up of the carbonates of lime and magnesia and sulphate of lime. These marls, as well as the above impure gypsum, are admirably adapted for agricultural use as amending manures, and are not used at all to the extent which their value would justify.

The most interesting gypsums in a general point of view are certainly the tertiary, or those of the plains, or hills of comparatively modern formation. They are characterized by the presence of fossil bones of extinct animals, both *mammifera* and birds, by shells, and a large proportion of carbonate of lime, which gives them the property of effervescing with acids, and the title of limestone gypsums. Such are the gypsums of the environs of Paris, as at the heights of Montmartre, which contain crystallized sulphate of lime in many forms, but most commonly the lenticular and lance-shaped.

Sulphate of lime occurs either as a dense compound without water, and is called *anhydrite* from that circumstance, or with combined water, which is its most ordinary state. Of the latter there are six sub-species; sparry gypsum or selenite in a variety of crystalline forms; the foliated granular; the compact; the fibrous; the scaly foliated; the earthy.

The prevailing color is white, with various shades of gray, blue, red, and yellow. More or less translucent. Soft, sectile, yielding to the nail. Specific gravity 2·2. Water dissolves about one five-hundredth part of its weight of gypsum, when it acquires the quality of hardness, with the characteristic selenitic taste. When exposed on red hot coals, it decrepitates, becomes white, and splits into a great many brittle plates. At the heat of a baker's oven, or about 400° Fahr., the combined water of gypsum escapes with a species of ebullition. At a higher temperature the particles get indurated. When rightly calcined and pulverized, gypsum is mixed with water to the consistence of cream, and poured into moulds by the manufacturers of stucco ornaments and statues. A species of rapid crystallization ensues, and the thin paste soon acquires a solid consistence, which is increased by drying the figure in proper stoves. During the consolidation of the plaster, its volume expands into the finest lines of the mould, so as to give a sharp and faithful impression.

The plaster stone of the Paris basin

contains about 12 *per cent.* of carbonate of lime. This body, ground and mixed with water, forms an adhesive mortar much used in building, as it fixes very speedily. Works executed with pure gypsum never become so hard as those made with the calcareous kind; and hence it might be proper to add a certain portion of white slaked lime to our calcined gypsum, in order to give the stucco this valuable property. Colored stuccos of great solidity are made by adding to a clear solution of glue any desired coloring tincture, and mixing in the proper quantity of the calcined calcareous gypsum.

The compact, fine-grained, gypseous alabaster is often cut into various ornamental figures, such as vases, statuary groups, &c., which take a high polish and look beautiful, but from their softness are easily injured, and require to be kept enclosed within a glass shade.

In America and France, the virtues of gypsum in fertilizing land have been highly extolled.

Pure gypsum consists of lime 28, sulphuric acid 40, water 18, which are the respective weights of its prime equivalent parts.

M. Gay Lussac, in a short notice on the setting of gypsum, says that the purest plasters are those which harden least, and that the addition of lime is of no use toward promoting their solidity, nor can the heat proper for boiling gypsum ever expel the carbonic acid gas from the calcareous carbonate present in the gypsum of Montmartre. He conceives that a *hard* plaster-stone having lost its water, will resume more solidity in returning to its first state than a plaster-stone naturally tender or soft; and that it is the primitive molecular arrangement which is regenerated.

Franklin was the first to call public attention to the use of gypsum as a manure, and by the experiment of sowing it in the form of letters on a field, which when the grass grew could be read by its superior growth and verdure, tested fully its value. It is now justly considered indispensable to good farming, but it exerts its chief value only on dry or drained soils. Sands and loams feel its influence at once. Two pecks on sandy soils and fifteen bushels on clays have been applied: the farmers of Western New-York look upon two bushels per acre as sufficient. It is chiefly valuable to leguminous plants, as pease, beans, clover, saintfoin, and lucerne. It should be sown broadcast in spring when the young leaves are started; it then throws turnips on to grow so quick that they escape the ravages of the fly. On account of dissolving so sparingly in water, it is best sown in wet weather.

Calcined gypsum after being moistened with a solution of alum, and again burned, acquires much greater hardness and solidity. A Mr. Kreating has recommended for the same purpose a solution of 1 lb borax in 9 lbs. of water, which is poured over the calcined fragments of gypsum. They are then kept at a strong red heat for six hours, ground to a powder, and worked. The effect is better if a lb. of tartar and twice the quantity of water were added to the solution.

HAIR. The characteristic covering of the mammiferous class of animals. It consists of slender, more or less elongated, horny filaments, secreted by a matrix, consisting of a conical gland or bulb, and a capsule, which is situated in the mesh-work of the corium, or true skin. The hairs pass out through canals in the corium, which are lined by a thin layer of cuticle adherent to the base of the hair: the straightness or curl of the hair depends on the form of the canal through which it passes. Spines, bristles, fur, and wool, are all modifications of hair, having the same chemical composition, mode of formation, and general structure.

In the spines of the porcupine, the bulb secretes a fluted pith, and the capsule invests it with a horny sheath, the transparency of which allows the ridges of the central part to be seen. In the spines of the hedgehog, the spine-like whiskers of the walrus, and the bristles of the hog, the twofold structure of the hair is very conspicuous: but in the finer kind of hair, as in the human head and beard, the central pith can only be demonstrated in fine transverse sections viewed with the microscope. Some kinds of hair, as of the human head, the mane and tail of the horse, are perennial, and grow continuously by a persistent activity of the formative capsule and pulp; other kinds, as the ordinary hair of the horse, cow, and deer, are annual, and the coat is shed at particular seasons. In the deer the horns are shed contemporaneously with the deciduous hair.

Many quadrupeds, especially those of cold climates, have two kinds of hair: a long and coarse kind, forming their visible external covering; and a shorter, finer, and more abundant kind, which lies close to the skin, and called "fur." It is one of the processes in the arts to remove the close hairs, and leave the fur attached to the dried skin, as in the preparation of seal-skin, &c. The peculiar characteristic of wool, and that on which its valuable qualities chiefly depend, is the serrated character of its surface, arising from its structure, which consists of a series or succession of inverted cones, the base of each being directed from the root of the woolly fibre, and receiving the apex of the succeeding cone. It results from this structure that the pressure to which the workman subjects the wool in moving it backwards and forwards brings the fibres together, and multiplies their points of contact. The agitation gives to each hair a progressive motion towards the root, and the serrations of one hair fix themselves on those of another hair which happens to have its root turned in the opposite direction, and the mass at length assumes the compact form which is termed "felted" wool. The microscope has likewise demonstrated various other remarkable modifications in the form of the hair in different quadrupeds. In the mole, each hair is alternately constricted and expanded from its root to its apex, whereby it readily assumes any position, and lies flat and smooth, either towards the head when the little burrower is retrograding in his subterranean galleries, or in the contrary direction when moving forwards. The organization of the hair is such as to allow of its undergoing certain changes when once formed, according to the state of health and general condition of the rest of the frame, and even to be affected by loss of color in consequence of violent mental emotions in the human subject. Some of the lower animals, as the Alpine hare, are subject to periodical change of color of their fur, by which it is made to harmonize with the prevailing hue of the ground which they habitually traverse.

The chemical properties of hair were first pointed out by Mr. Hatchett. It chiefly consists of an indurated albumen, and when boiled with water, it yields a portion of gelatine. Soft flexible hair, which easily loses its curl, is that which is most gelatinous. Vauquelin discovered two kinds of oil in hair: the one colorless, and in all hair; the other colored, and imparting according to its color the peculiar tint of hair in the individual.

HAIR PENCILS or BRUSHES for painting. Two sorts are made; those with coarse hair, as that of the swine, the wild boar, the dog, &c., which are attached usually to short wooden rods as handles; those are commonly called *brushes;* and hair pencils, properly so called, which are composed of very fine hairs, as of the minever, the marten, the badger, the polecat, &c. These are mounted in a quill when they are small or of moderate size, but when larger than a quill, they are mounted in white iron-tubes.

The most essential quality of a good pencil is to form a fine point, so that all the hairs without exception may be united when they are moistend by laying them upon the tongue, or drawing them through the lips. When hairs present the form of an elongated cone in a pencil, their point only can be used. The whole difficulty consists after the hairs are cleansed, in arranging them together so that all their points may lie in the same horizontal plane. We must wash the tails of the animals whose hairs are to be used, by scouring them in a solution of alum till they be quite free from grease, and then steeping them for 24 hours in lukewarm water. We next squeeze out the water by pressing them strongly from the root to the tip, in order to lay the hairs as smooth as possible. They are to be dried with pressure in linen cloths, combed in the longitudinal direction with a very fine-toothed comb, finally wrapped up in fine linen, and dried. When perfectly dry, the hairs are seized with pincers, cut across close to the skin, and arranged in separate heaps, according to their respective lengths.

Each of these little heaps is placed separately, one after the other, in small tin pans with flat bottoms, with the tip of the hair upwards. On striking the bottom of the pan slightly upon a table, the hairs get arranged parallel to each other, and their delicate points rise more or less according to their lengths. The longer ones are to be picked out and made into so many parcels, whereby each parcel may be composed of equally long hairs. The perfection of the pencil depends upon this equality; the tapering point being produced simply by the attenuation of the tips.

A pinch of one of these parcels is then taken, of a thickness corresponding to the intended size of the pencil; it is set in a little tin pan, with its tips undermost, and is shaken by striking the pan on the table as before. The root end of the hairs being tied by the fisherman's or seaman's knot with a fine thread, it is taken out of the pan, and then hooped with stronger thread or twine; the knot being drawn very tight by means of two little sticks. The distance from the tips at which these ligatures are placed is of course relative to the nature of the hair, and the desired length of the pencil. The base of the pencil must be trimmed flat with a pair of scissors.

Nothing now remains to be done but to mount the pencils in quill or tin-plate tubes, as above described. The quills are those of swans, geese, ducks, lapwings, pigeons, or larks, according to the size of the pencil. They are steeped during 24 hours in water, to swell and soften them, and to prevent the chance of their splitting when the hair-brush is pressed into them. The brush of hair is introduced by its tips into the larger end of the cut quill, having previously drawn them to a point with the lips, when it is pushed forwards with a wire of the same diameter, till it comes out at the other and narrower end of the quill.

HANDSPIKE. A wooden lever used on shipboard for working the windlass and capstan, one end of which is squared to fit the holes of the capstan-head and in the barrel of the windlass.

HANK, in spinning, the name given to two or more skeins of yarn, silk, or cotton, when tied together.

HARBOR, has been defined to be a piece of water communicating with the sea, or with a navigable river or lake, having depth sufficient to floats ships of considerable burden, where there is convenient anchorage, and where ships may lie, load, and unload, screened from the winds and beyond the reach of the tide.

HARD BODIES, in Natural Philosophy, are such as resist any pressure or percussion whatever, in opposition to soft bodies, the parts of which readily yield to pressure, and do not recover themselves; and to elastic bodies, the parts of which also yield to pressure or impact, but presently recover themselves when the disturbing force ceases to act.

HARDNESS. In physics, that quality of bodies in virtue of which their particles resist the action of any external force tending to alter their relative positions, or to impart to them any motion in respect of each other. Newton supposes the primary particles of all bodies to be perfectly hard, and not capable of being broken or divided by any power in nature; but we are still too little acquainted with the constitution of matter to determine with any certainty the conditions of the elementary particles which render bodies hard, brittle, and elastic.

HARDNESS. In Mineralogy. Minerals may occasionally be distinguished and identified by their relative degrees of hardness; to specify which various scales have been suggested, among which that of Mohs is perhaps the most simple. According to it the relative degrees of hardness are expressed in numbers, referring to the following standard substances, which are easily obtained in a state of purity, or crystallized; namely,

1. Talc.
2. Rock-salt.
3. Calc-spar.
4. Fluor-spar.
5. Apatite.
6. Adularia (Feldspar).
7. Rock-crystal.
8. Topaz.
9. Corundum.
10. Diamond.

Any mineral, which neither scratches nor is scratched by any one of the above substances, is said to possess the hardness expressed by the attached number. Thus if a mineral neither scratches nor is scratched by calcareous spar, its hardness is represented by 3; if it scratches feldspar and not rock-crystal, its hardness is stated to be between 6 and 7.

HARDWARE, is used to signify every kind of goods manufactured from metals, comprising iron, brass, steel, and copper articles of all descriptions. The hardware manufacture is one of the most important carried on in Great Britain. Its principal seats are Birmingham and Sheffield, which furnish immense quantities of knives, razors, scissors, gilt and plated ware, fire-arms, &c., both for home consumption and exportation.

HARROW. In agriculture, a rectangular frame with a number of spikes inserted in it on one side. This frame, when dragged over ploughed land, breaks the furrow slices into small pieces, for the purpose of preparing the land for seed in some cases, and for covering the seed in others. The most common form of the frame of the harrow is rectangular, and the usual material employed is wood, with the spikes of iron; but in some cases both the frame and the spikes are of wood, and in others both are of iron. Occasionally the frame is a circle of iron, and the spikes are inserted in it, at such distances that when the frame is drawn along in a straight line, the spikes, or tines as they are technically termed, pass through every part of the soil traversed by the frame or harrow. In the common kinds of harrows the spikes are inserted at right angles to the frame: but in the improved forms they are inserted at an oblique angle, or pointing forwards, by which means the harrow is drawn much more easily through the soil. The best implement of this description at present in use is Finlayson's harrow. This implement, by means of a long lever, can be regulated to such a nicety as to stir the soil to the depth of only one or two inches, for the purpose of covering grass or clover seeds; or it can be pressed into it of such a depth as to serve, in the case of stubble lands, instead of ploughing. Wilkie's harrow and Kirkwood's harrow can be used for similar purposes. They differ nothing from Finlayson's in principle; but being on a smaller scale can be worked with fewer horses than Finlayson's, which commonly requires four or six.

HARROWING. The process of drawing a harrow through the soil for the purpose of reducing it to a level, of covering seed, or of turning up weeds in ploughed ground, or moss in grass lands. In agriculture the harrow is drawn by horses or oxen; and in market-gardening, where a light harrow is sometimes employed, by men. In either case the more rapid the motion of the harrow, up to a certain point, the more efficient will be its operation. For meadow lands, the object of harrowing is to disperse the little heaps of earth raised during winter and early spring by moles and worms; and for this purpose the harrows in some parts of the country are turned upside down; while in others, less advanced, thorn branches are tucked into a frame resembling a harrow, and dragged over the surface for the purpose of effecting the same object. This is called a bush harrow.

HARTSHORN, SPIRIT OF. An impure solution of carbonate of ammonia, obtained by the destructive distillation of hartshorn or any kind of bone. It is now never made by this process, but by a direct solution of the pure carbonate of ammonia.

HAT MANUFACTURE. The materials used for making hats are, besides silk, the fur of hares and rabbits chosen from the long hair; together with wool and beaver and nutria. The two latter are reserved for the finer hats. The body of a beaver hat is made of fine wool and coarse fur mixed and felted together, then stiffened and shaped; the covering consists of a coat of beaver-fur felted upon the body. Cheap hats have their bodies made of coarse wool, and their coverings of coarse fur or fine wool. The body or foundation of a good beaver hat, is at present made of 8 parts of rabbit's fur, 3 parts of Saxony wool, and 1 part of lama, vicunia, or red wool. About two ounces and a half of the above mixture are sufficient for one hat, and these are placed in the hands of the *bower*; his tool is a bow or bent ashen staff, from 5 to 7 feet long, having a strong catgut string stretched over a bridge at each end, and suspended at its middle by a cord to the ceiling, so as to hang nearly level with the work bench, and a small space above it. The wool and coarser fur are laid in their somewhat matted state upon this bench, when the bower, grasping the bent rod with his left hand, and *by means of a small wooden catch plucking the string with his right*, makes it vibrate smartly against the fibrous substances, so as to disentangle them, toss them up in the air, and curiously arrange themselves in a pretty uniform layer or fleece. A skilful bower is a valuable workman. The bowed materials of one hat are spread out and divided into two portions, each of which is compressed, first with a light wicker frame, and next under a piece of oil cloth or leather, called a hardening skin, till by pressing the hands backward and forward all over the skin, the filaments are linked together by their serrations into a somewhat coherent fleece of a triangular shape. The two halves or "bats" are then formed into a cap; one of them is covered in its middle with a 8-cornered piece of paper, smaller than itself, so that its edges may be folded over the paper, and by overlapping each other a little, form a complete envelope to the paper; the junctions are then partially felted together by rubbing them hard, care being taken to keep the base of the triangle open by means of the paper; the second bat being made to enclose the first by a similar process of folding and friction. This double cap, with its enclosed sheet of paper, is next rolled up in a damp cloth and kneaded with the hands in every direction, during which it is unfolded and creased up again in different forms, whereby the two layers get thoroughly incorporated into one body; thus, on withdrawing the paper, a hollow cone is obtained. This cap is next taken and dipped occasionally into a weak acid solution made of vitriol and water and is also wrought by hands or with the roller on the sloping planks. This constitutes *fulling* or thickening and is continued 4 or 5 hours; knots are picked out and fresh felt added by a wet brush. The beaver is applied at the end of this operation on beaver hats. The foundation of men's hats, upon the outside of which the beaver, down, or other fine fur is laid, to produce a nap, is usually made of wool felted together by hand and formed first, into conical caps, which are afterwards stretched and moulded to the desired shape. Hemp and felt are also used as foundations.

Stopping, or thickening the thin spots, seen by looking through the body, is performed by daubing on additional stuff with successive applications of the hot acidulous liquor from a brush dipped into the kettle, until the body be sufficiently shrunk and made uniform. After drying, it is stiffened with varnish composition rubbed in with a brush; the inside surface being more copiously imbued with it than the outer; while the brim is peculiarly charged with the stiffening.

When once more dried, the body is ready to be *covered*, which is done at the *battery*. The first cover of beaver or napping, which has been previously *bowed*, is strewed equally over the body, and patted on with a brush moistened with the hot liquor, until it gets incorporated; the cut ends towards the root, being the points which spontaneously intrude. The body is now put into a coarse hair cloth, then dipped and rolled in the hot liquor, until the root ends of the beaver are thoroughly worked in. This is technically called rolling off, or *roughing*. A strip for the brim, round the edge of the inside, is treated in the same way; whereby every thing is ready for the second cover (of beaver), which is incorporated in like manner; the rolling, &c., being continued, till a uniform, close, and well-felted hood is formed.

The hat is now ready to receive its proper shape. For this purpose the workman turns up the edge or brim to the depth of about 1½ inch, and then returns the point of the cone back again through the axis of the cap, so as to produce another inner fold of the same depth. A third fold is produced by returning the point of the cone, and so on till the point resembles a flat circular piece having a number of concentric folds. In this state it is laid upon the plank, and wetted with the liquor. The workman pulls out the point with his fingers, and presses it down with his hand, turning it at the same time round on its centre upon the plank, till a flat portion, equal to the crown of the hat, is rubbed out. This flat crown is now placed upon a block, and, by pressing a string called a *commander*, down the sides of the block, he forces the parts adjacent to the crown, to assume a cylindrical figure. The brim now appears like a puckered appendage round the cylindrical cone; but the proper figure is next given to it, by working and rubbing it. The body is rendered waterproof and stiff by being imbued with a varnish composed of shellac, sandarach, mastic, and other resins dissolved in alcohol or naptha.

The hat being dried, its nap is raised or loosened with a wire brush or card, and sometimes it is previously pounced or rubbed with pumice, to take off the coarser parts, and afterwards rubbed over with seal-skin. The hat is now tied with pack-thread upon its block, and is afterwards dyed. See HAT-DYEING.

The dyed hats are now removed to the stiffening shop. Beer grounds are next applied on the inside of the crown, for the purpose of preventing the glue from coming through; and when the beer grounds are dried, glue (gum Senegal is sometimes used) a little thinner than that used by carpenters, is laid with a brush on the inside of the crown, and the lower surface of the brim.

The hat is then softened by exposure to steam, on the steaming basin, and is brushed and ironed till it receives the proper gloss. It is lastly cut round at the brim by a knife fixed at the end of a gauge, which rests against the crown. The brim, however, is not cut entirely through, but is torn off so as to leave an edging of beaver round the external rim of the hat. The crown being tied up in a gauze paper, which is neatly ironed down, is then ready for the last operations of lining and binding.

The furs and wools of which hats are manufactured contain, in their early stage of preparation, *hemps* and *hairs*, which must be removed in order to produce a material for the better description of hats. This separation is effected by a sort of winnowing machine, which wafts away the finer and lighter parts of the furs and wools from the coarser.

Silk hats, for several years after they were manufactured, were liable to two objections; first, the body or shell over which the silk covering is laid, was, from its hardness, apt to hurt the head; second, the edge of the crown being much exposed to blows, the silk nap soon got abraded, so as to lay bare the cotton foundation, which is not capable of taking so fine a black dye as the silk; whence the hat assumed a shabby appearance. Messrs. Mayhew and White, of London, hat-manufacturers, remedied these defects, by making the hat body of stuff or wool, and relieving the stiffness of the inner part round the brim, by attaching a coating of beaver upon the under side of the brim, so as to render the hat pliable. Round the edge of the tip or crown, a quantity of what is called stop wool is to be attached by the ordinary operation of bowing, which will render the edge soft and elastic. The hat is to be afterwards dyed of a good black color, both outside and inside; and being then properly stiffened and blocked, is ready for the covering of silk.

The plush employed for covering silk hats, is a raised nap or pile woven usually upon a cotton foundation; and the cotton, being incapable of receiving the same brilliant black dye as the silk, renders the hat apt to turn brown whenever the silk nap is partially worn off. The way to counteract this evil is by making the foundation of the plush entirely of silk. To these two improvements, now pretty generally introduced, the present excellence of the silk hats may be, in a good measure, ascribed.

In a great hat factory women are employed, at respectable wages, in plucking the beaver skins, cropping off the fur, sorting various qualities of wool, plucking and cutting rabbit's fur, shearing the nap of the blocked hat, picking out unseemly filaments of fur, and in trimming the hats; that is, lining and binding them.

With regard to the *stiffening* of hats, Dr. Ure gives the following receipts as furnished by a skilful operator with the following valuable information:—All the solutions of gums which I have hitherto seen prepared by hatters, have not been perfect, but, in a certain degree, a mixture, more or less, of the gums, which are merely suspended, owing to the consistency of the composition. When this is thinned by the addition of spirit, and allowed to stand, it lets fall a curdy looking sediment, and to this circumstance may be ascribed the frequent breaking of hats. My method of proceeding is, first, to dissolve the gums by agitation in twice the due quantity of spirits, whether of wood or wine, and then, after complete solution, draw off one half the spirits in a still, so as to bring the stiffening to a proper consistency. No sediment subsequently appears on diluting this solution, however much it may be done.

Both the spirit and alkali stiffenings for hats made by the following two receipts, have been tried by some of the first houses in the trade, and have been much approved of:—

Spirit Stiffening.

7 pounds of fine orange shellac.
2 pounds of gum sandarac.
4 ounces of gum mastic.
Half a pound of amber resin.
1 pint of solution of copal.
1 gallon of spirit of wine or wood naptha.

The shellac, sandarac, mastic, and resin, are dissolved in the spirit, and the solution of copal is added last.

Alkali Stiffening.

7 pounds of common black shellac.
1 pound of amber resin.
4 ounces of gum rhus.
6 ounces of borax.
Half a pint of solution of copal.

HAT-DYEING. The ordinary bath for dyeing hats, employed by the London manufacturers, consists, for 12 dozen, of—

144 pounds of logwood.
12 pounds of green sulphate of iron, or copperas.
7½ pounds of verdigris.

The copper is usually made of a semi-cylindrical shape, and should be surrounded with an iron jacket or case, into which steam may be admitted, so as to raise the temperature of the interior bath to 190° F., but no higher, otherwise the heat is apt to affect the stiffening varnish, called the gum, with which the body of the hat has been imbued. The logwood having been introduced and digested for some time, the copperas and verdigris are added in successive quantities, and in the above proportions, along with every successive two or three dozens of hats, suspended upon the dipping machine. Each set of hats, after being exposed to the bath with occasional airings during 40 minutes, is taken off the pegs, and laid out upon the ground to be more completely blackened by the peroxydizement of the iron with the atmospheric oxygen. In 3 or 4 hours the dyeing is completed. When fully dyed, the hats are well washed in running water.

HEART WHEEL. The name given to a well-known mechanical contrivance for converting a circular motion into an alternating rectilinear one, common in cotton mills. It is an ellipse turned either on an axle, or by means of a winch and handle on one of its foci, or its centre, on whose edge a movable point or circle presses; the latter receives an alternating motion from the circumference of the ellipse, which in its revolution presses it to different distances from the centre of motion. The practical disadvantages of this contrivance are the inequality of pressure and of moving force which will be required at different parts of the rotation of the ellipse, and the consequent wearing of some parts of it faster than others.

HEAVY SPAR. Native sulphate of baryta. This is a common mineral in many mining districts. It occurs in several crystalline forms, of which the cleavage is a right rhomboidal prism; it also occurs fibrous, radiated, and stalactitic. Some beautiful specimens of the latter variety have been found in Derbyshire of a brown color. The crystals are usually white, or nearly colorless. The specific gravity of sulphate of baryta is 4·1 to 4·6. It consists of 77 baryta, 40 sulphuric acid, its equivalent being 117. It enters into the composition of some kinds of pottery, but its chief consumption is in the adulteration of white lead. It is a mineral common in the States of New-York and New Jersey.

HECKLE is an implement for dissevering the filaments of flax, and laying them in parallel stricks or tresses. *See* FLAX.

HELIOCHROMATYPE. Under the article Daguerreotype, notice has been taken of the attempts of Becquerel and Hill, to produce naturally colored impressions on the silver plate. In March of this year (1851), M. Niepce de St. Victor communicated to the Paris Academy of Sciences, a memoir showing the manner of taking the natural colors. Having formed the idea that there might be some relation between the color that a substance communicates to flame, and the color that light produces on a plate of silver chloridized with the substance that colors the flame, he undertook the experiments which led to his success. He found it necessary to expose the plate to chlorine, and then coat it with the chloride of the particular metal he was investigating; no other salts acted similarly to the chlorides. *Dry* chlorine does not produce any effect, but when the plate is immersed in the liquid chlorine, or exposed to the aqueous vapor, the colors are all reproduced. The mode of operating is thus: The bath is made of chlorine 1 part, and 8 parts of water. When hydrochloric acid, with a salt of copper, is used, it is diluted with 1-10 of water. The liquid chlorine should not be concentrated, as good yellows are not then obtained. Clear solutions and stoppered bottles should be used. The purest silver plate is preferable for these experiments; this is cleaned with ammonia and tripoli, then plunged into the bath, and left there for some minutes in order to receive a sufficiently heavy coating, the plate is then removed, rinsed with water, and dried by a spirit-lamp. In the bath it takes on a dark color, almost black, and though it will take the colors, yet the ground will be black. In order to have a clearer ground and a quicker operation, the plate is changed by heat to a cherry red, when the dark plate is heated by a lamp placed below it. It passes through the following tints, *brownish red*, *cherry red*, *bright red*, *reddish white*, *whitish*. In the last stage it has lost the power of producing images. The plate should only be brought to the cherry red condition. It is then to be exposed in the camera. To obtain a picture it requires two hours. This must be owing to Niepce's not using any accelerator; he mentions fluoride of soda, chloric acid, and the chlorates as worthy of trial for this purpose. These images disappear very quickly, and Niepce has not been successful in fixing them; exposing the plate to the flame of alcohol containing chloride of sodium or muriate of ammonia, partially succeeds. The chlorides which, when employed alone, act upon the silver plate, so as to make it take all the several colors of the model, are the chlorides of copper, of iron, of nickel, of potassium, and the hypochlorites of soda and lime, as well as liquid chlorine.

It is evident from the foregoing, that Heliochromatype is yet but in its infancy, and cannot be practically applied as yet.

HELIOTROPE is a variety of jasper, mixed with chlorite, green earth, and diallage; occasionally marked with blood-red points; whence its vulgar name of *blood-stone*.

HEMATINE is the name given by its discoverer, Chevreul, to a crystalline substance, of a pale pink color, and brilliant lustre when viewed in a lens, which he extracted from logwood, the *hæmatoxylon Campechianum* of botanists. It is, in fact, the characteristic principle of this dye-wood. To procure hematine, digest, during a few hours, ground logwood in water heated to a temperature of about 180° F.; filter the liquor, evaporate it to dryness by a steam bath, and put the extract in alcohol of 0·835 for a day. Then filter anew, and after having inspissated the alcohol solution by evaporation, pour it into a little water, evaporate gently again, and then leave it to itself in a cool place. In this way a considerable quantity of crystals of hematine will be obtained, which may be readily purified by washing with alcohol and drying.

When subjected to dry distillation in a retort, hematine affords all the usual products of vegetable bodies, along with a little ammonia; which proves the presence of azote. Boiling water dissolves it abundantly, and assumes an orange-red color, which passes into yellow by cooling, but becomes red again with heat. Sulphurous acid destroys the color of solution of hematine. Potash and ammonia convert into a dark purple-red tint, the pale solution of hematine; when these alkalis are added in large quantity, they make the color violet blue, then brown-red, and lastly brown-yellow. By this time, the hematine has become decomposed, and cannot be restored to its pristine state by neutralizing the alkalies with acids.

The waters of baryta, strontia, and lime exercise an analogous power of decomposition; but they eventually precipitate the changed coloring matter.

A red solution of hematine subjected to a current of sulphureted hydrogen becomes yellow; but it resumes its original hue when the sulphureted hydrogen is removed by a little potash.

The protoxyde of lead, the protoxyde of tin, the hydrate of peroxyde of iron, the hydrate of oxydes of copper and nickel, oxyde of bismuth, combine with hematine, and color it blue with more or less of a violet cast.

Hematine precipitates glue from its solution in reddish flocks. This substance has not hitherto been employed in its pure state; but as it constitutes the active principle of logwood, it enters as an ingredient into all the colors made with that dye-stuff.

These colors are principally violet and black. Chevreul has proposed hematine as an excellent test of acidity.

HEMATITE is a native reddish-brown peroxyde of iron, consisting of oxygen 30·66; iron 69·34. It is the kidney ore of Cumberland, which is smelted at Ulverstone with charcoal, into excellent steel iron. It is one of the most abundant and valuable of the iron ores in the United States. *See* IRON.

HEMP. The fibres of the cannabis sativa; a plant grown extensively in this country, but mostly in Kentucky and Missouri. It is a native of India and Persia, and was thence introduced into Europe. Though much grown here, yet more is imported from Russia. It grows wild in many waste places. It grows well on strong soils, and hence on newly cleared lands. Soon after flowering, the male plants are pulled, and the female plants let to remain some weeks longer to mature the seed. These do not preserve their vitality longer than a year, owing to the large quantity of oil in them. The males should be tied immediately in bundles, the roots cut off while fresh, the upper leaves also beaten off, and it is the most eligible practice to immerse them in water without delaying for rotting. The females, which are three times more numerous than males, should be pulled very carefully, without shaking or inclining the summits, and the flail should not be used, as it bruises the seed. This, when separated, should be spread out and turned at intervals, and exposed to a current of air; otherwise they ferment. The process of rotting consists in the decomposition of the substance which envelopes and unites the fibres, and takes place much more rapidly in stagnant pools than in running water or extensive lakes, in warm weather than the reverse. The time requisite varies from five to fifteen days, even in stagnant water. The water in which hemp has been rotted has a disagreeable odor and taste, proving fatal to fishes, and should be distant from any inhabited place, lest it engender pestilential diseases. When water is not at hand, hemp is rotted in the open air, by spreading it at night upon the green-sward, and heaping it together in the morning, before the sun's rays have much power. In wet weather it may be left on the ground during the whole day; and should the nights be very dry, it is better to water it. This process is called *dew-rotting*, and is very tedious, requiring three, six, or even eight weeks. Another method again, is by placing it in a pit, and covering it over with about one foot of earth, after having watered it abundantly a single time; but even this method requires double the time of water. After being rotted and rapidly dried, it is ready for canting, beating, &c., but these subsequent manipulations are found by experience to be very unhealthy, probably from the fine dust created and flying about.

J. T. Crook & Co., Maysville, Ohio, have sent into the markets cordage manufactured by them, of rotted hemp, so kyanized by the use of antiseptic substances as to render it indestructible when exposed to the weather. Cordage, prepared like this, has been buried in a fungous heap, filled with decaying vegetable matter, for five years, without showing the least sign of decay. In respect to the preparing of this cordage in this country, they were compelled to use the *unrotted* hemp, since it is an established fact that antiseptics will not prevent the decay of vegetable matter, *when decay has actually commenced*, as is the case of dew and water-rotted hemp. The Russia hemp, in not being carried to the fermenting point in rotting, is not, like our water-rotted hemp, affected by decay, and is capable of being kyanized like the unrotted hemp, as has been successfully done in England, by the use of suitable antiseptics.

The comparative value of different sorts of hemp, as it regards durability, is easily and speedly tested by any one, since nearly all kinds are very short-lived when exposed to causes favorable to decay. The Manilla will last some four or five months as used in the summer season upon our steamboats—the *Sisal*, which is often sold in the west as manilla, will not last much more than half as long—the Russian hemp, when kept moist and warm, will lose its strength in about three weeks—the American water-rotted in two weeks, and the dew-rotted in from five to ten days. The unrotted hemp, without being kyanized, will not last longer than the dew-rotted, and will even show more signs of putrefaction before losing its strength.

The color and appearance of this cordage is similar to the Russia or water-rotted hemp. The strength is greater than either, while it is not "frayed down" like Manilla, by friction.

Dr. Leavitt has devised a method of preparing hemp, which consists of a hemp-brake of ingenious construction and great strength, propelled by a steam engine, breaking hemp at the rate of two pounds per minute, 1200 pounds in ten hours; and delivering the hemp in such condition as to be more easily and speedily heckled upon the common hand-heckle, than the dew-rotted hemp of the common hand-brake, and with quite as little, if not less waste. The cleaning apparatus is also thought to be likely to prove equally effective when furnished, as its simplicity and adaptation seem to warrant this conclusion. More than the whole of the fuel necessary for one steam engine, will be furnished, it is said, from the hemp itself, by three brakes, and is supplied to the furnace without necessity of a fireman.

The hemp-brakes stand in a line over a strong grating, beneath which is a trough, whose sides, inclined inward, receive and deposit upon an endless band, running in the direction of the furnace, all the woody matter falling from the brakes and carrying it to a funnel, through which it is thrown into the furnace and scattered in its bed, igniting instantly, and keeping up an intensely hot fire. A man and two boys are sufficient to attend each brake with ease, and a third one can bear off the hemp from the three brakes, delivered in bands or endless roving to be passed through the various subsequent machinery, a portion of which is designed to supersede the wasteful heckling now in use, avoiding the manufacture of tow entirely. Connected with it is also to be an apparatus for supplying the powerful antiseptic substances now in use in the manufactories of ship cordage and canvas in England, the efficacy of which has been so severely tested in the *Niger expedition*, and on the western coast of South America, so celebrated for its production in the cordage and sails of shipping exposed to that climate. The material to be used will be made at the factory, and will not cost over $5 for each ton of hemp.

Dr. Leavitt's efforts will prove of great value to our commercial interests, as well as probably greatly encourage the agriculturists whose attention is devoted to the cultivation of hemp, and the amount of this product will doubtless be much increased at the west.

By a recent trial it appears that the strength of a rope of this unrotted hemp, was much greater than those of American water-rotted Russia or steam hemp.

HEMP-BRAKE. Mr. Colver, of Missouri, has invented a hemp-brake, which with four men and two boys, will break 2,240 lbs. in a day. This machine is precisely on the principle of the hand-brake, the swords moving with great rapidity. On each machine there are two places for breaking, and two for cleaning the hemp, the ends of the swords serving admirably for the latter purpose. The

several properties render it superior to quassia, gentian, etc.

HORDEIN. A modification of starch, containing 55 per cent. of barley meal.

HORN. The hollow horns of the ox, goat, &c., the hoof, the horny claw and nail, and the scale of certain insects, as the shell of the tortoise, resemble each other in chemical characters; but they differ very widely from stag's horn, ivory, &c. Horn is distinguished from bone, in being softened very completely by heat, either applied immediately, or through the medium of water, so as to be readily bent to any shape, and to adhere to other pieces of horn in the same state. It contains but a small portion of gelatine, and in this it differs from bone, which contains a great deal. Horn consists chiefly of condensed albumen, combined with a small and varying portion of gelatine, with a small part of phosphate of lime. The fixed alkalies readily dissolve horn into a yellow saponaceous liquor.

HORN, MANUFACTURE OF ARTICLES IN. Horn, particularly of oxen, cows, goats, and sheep, is a substance soft, semi-transparent, and susceptible of being cut and pressed into a variety of forms; it is this property that distinguishes it from bone.

These valuable properties being known render horn susceptible of being employed in a variety of works fit for the turner, comb, and snuff-box maker. The kind of horn most to be preferred, is that of goats and sheep, from its being whiter and more transparent than the horn of any other animal. When horn is wanted in sheets or plates, it must be steeped in water, to be able to separate the pith from the kernel, for about fifteen days in summer, and a month in winter; and when it is soaked it must be taken out by one end and well shaken and rubbed, in order to get out the pith; after which it must be put for half an hour in boiling water, and then taken out, and the surface sawed even, lengthwise; it must again be put into the boiling water to soften it, so as to render it capable of separating; then with the help of a small iron chisel it can be divided into sheets or leaves. The thick pieces will form three leaves, those which are thin will form only two, whilst young horn, which is only one quarter of an inch thick, will form only one. These plates or leaves must again be put into the boiling water, and when they are sufficiently soft, they must be well worked with a sharp cutting instrument, to render those parts that are thick even and uniform; it must be put once more into the boiling water, and then carried to the press. Mr. J. James has contrived a method of opening up the horns of cattle, by which he avoids the risk of scorching or frizzing, which is apt to happen in heating them over an open fire. He takes a solid block of iron pierced with a conical hole, which is fitted with a conical iron plug, heats them in a stove to the temperature of melting lead, and having previously cut up the horn lengthwise on one side with a saw, he inserts its narrow end into the hole, and drives the plug into it with a mallet. By the heat of the irons, the horn gets so softened in the course of about a minute, as to bear flatting out in the usual way.

At the bottom of the press employed, there must be a strong block, in which is formed a cavity of nine inches square, and of a proportionate depth; the sheets of horn are to be laid within this cavity, in the following manner: at the bottom, first a sheet of hot iron, upon this a sheet of horn, then again a sheet of hot iron, and so on, taking care to place at the top a plate of iron even with the last, and the press must then be screwed down tight.

There is a more expeditious process, at least in part, for reducing the horn into sheets, when it is wanted very even. After having sawed it with a very fine and sharp saw, the pieces must be put into a boiler used for the purpose, and then boiled until sufficiently soft, so as to be able to be split with pincers; then bring quickly the sheets of horn to the press, where they are to be placed in a strong vice, the clasps of which are iron, and larger than the sheets of horn, and screw the vice as quick and tight as possible; let it then cool in the press or vice, or it is as well to plunge the whole into cold water. The last mode is preferable, because the horn does not dry up in cooling. Now draw out the leaves of horn, and introduce other horn to undergo the same process. The horn so enlarged in pressing is to be submitted to the action of the saw, which ought to be set in an iron frame, if the horn is wanted to be cut with advantage, in sheets of any desired thickness, which cannot be done without adopting this mode. The thin sheets thus produced, must be kept constantly very warm between the plates of hot iron to preserve their softness. Every leaf must be loaded with a weight heavy enough to prevent its warping. To join the edges of these pieces of horn together, it is necessary to provide strong iron moulds suited to the shape of the article that is wanted, and to place the pieces in contact with copper plates, or with polished metal surfaces against them; when this is done, the whole should be put into a vice and screwed up tight, then plunged into boiling water, and after some time it is to be removed from thence, and immersed in cold water, which will cause the edges of the horn to cement together, and become perfectly united.

To complete the polish of the horn, the surface must be rubbed with sub-nitrate of bismouth, by the palm of the hand. The process is short and has this advantage—that it makes the horn dry promptly. When it is wished to spot the horn in imitation of tortoise shell, metallic solution must be employed as follows: To spot it red, a solution of gold in aqua regia must be employed; to spot it black, a solution of silver in nitric acid must be used; and for brown, a hot solution of mercury in nitric acid. The right side of the horn must be impregnated with those solutions, and they will assume the color intended. The brown spots can be produced on the horn by means of a paste made of red lead, with a solution of potash, which must be put in pieces on the horn, and subjected some time to the action of heat. The deepness of the brown shade depends upon the quantity of potash used in the paste, and the length of time the mixture lies on the horn. A decoction of Brazil wood, a solution of indigo with sulphuric acid, a decoction of saffron, and Barbary tree wood is used. After having employed these materials, the horn may be left for half a day in a strong solution of vinegar and alum.

HORNBLENDE. A mineral of a dark green or black color, abounding in oxide of iron, and entering into the composition of several of the trap rocks. It is the *amphibole* of Hauy. It often inclines to brown with every intermediate shade; nearly transparent in some varieties; in others opaque; brittle; hardness about the same with feldspar; specific gravity, 8·00. Three varieties, analyzed by Bonsdorf, gave the following results:

	White	*Green*	*Black*
Silex............	60·81	46·26	45·69
Magnesia..........	24·23	19·03	18 79
Lime..............	18·66	13·96	13·85
Alumine	0·26	11·48	12·18
Protoxide of iron..	0·15	8·43	7·32
Do. of magnanese.	0·00	9·26	0·22
Fluoric acid......	0·94	1·60	1·50
Water, &c.........	0·10	1·04	0·00

Of those varieties of the present species which have obtained distinct names, and which, in some systems of mineralogy, have ever been regarded as forming separate species, the following are the most remarkable, viz: *hornblende*, *tremolite*, *actynolite*, and certain kinds of asbestos.

HORNBLENDE SCHIST. A slaty variety of hornblende, generally including feldspar and grains of quartz: it is of a dark green or black color. Where clay slate is in contact with granite, it sometimes passes into hornblende slate.

HORSE POWER. It is well known among engineers that a horse is capable of raising a weight of about 150 lb. 220 feet high in a minute, and to continue exertions enabling him to do that for 8 hours a-day.

Multiply the number of pounds by the height to which they are raised in a minute, 150 × 220 gives 83,000 lb., and the power of a horse is generally expressed by a sum varying from 80,000 lb., to 36,000 lb., raised 1 foot high in a minute.

Bolton and Watt express it by 82,000lb.; Woolf, by 36,000 lb.; Tredgold, Palmer, and others, by 33,333 lb. One horse can draw horizontally as much as seven men.

In trains of machinery from ¼ to ⅓ is allowed for friction in calculating its equivalent of horse power.

HORSE. *Table of Power and Speed.* Let us suppose 15 to represent the greatest unloaded speed, and the square of 15, or 225, to represent the greatest load which can be sustained without moving; the following table gives for each degree of speed, from 1 to 15, the corresponding load and useful effect:—

Speed	0	1	2	8	4	5	6	7	8	9	10	11	12	13	14	15
Load	225	196	169	144	121	100	81	64	49	86	25	16	9	4	1	0
Effect	0	196	888	432	484	500	486	484	392	824	250	176	108	52	14	0

Thus, if the greatest unloaded speed of a horse be 15 miles an hour, and the greatest weight he is capable of sustaining, without moving, be divided into two hundred and twenty-five equal parts, his labor will be most advantageously employed if he be loaded with 100 of those parts, and travel at the rate of five miles an hour. If he be thus employed it will be found that he will carry a greater weight through a distance, in a given time, than under any circumstances.

A horse, upon a well-constructed railroad, can draw 10 tons at the rate of 2 miles per hour, or 5 tons 4 miles per hour.

The absolute force of the horse drawing horizontally is, on average, 770 lb. From various calculations it would appear when the period of continuance is made an element in the calculation, that the power of a horse working eight hours a day is on an average not more than an equivalent to that of five men working 10 hours; the most useful mode of applying a horse's power is in draught, and the worst is in carrying a load; it has been found that three men carrying each 100 lb., will ascend a hill with greater rapidity than one horse carrying 300 lb. The best disposition of the traces in draught is when they are perpendicular to the collar.

When a horse is employed in moving a machine in a circular path, the diameter of this path should not be less than 25 or 30 feet; 40 feet would be better than either.

HUMAN STRENGTH. An active man, working to the best advantage, can raise 10 lb. 10 feet in a second for 10 hours in the day, 100 lb. one foot in a second.

Absolute force of pressure with the hands was found by the dynamometer of Regnier to be on an average equal to 100 lb. Absolute force of a man lifting with both hands, 286 lb. The greatest average load which a man can support on his shoulders, for some seconds, is estimated at 330 lb.; and it is supposed that he can exert the same force in drawing vertically downwards.

The mean absolute force of a man, in drawing or pulling horizontally is found by the dynamometer to be 110 lb.; the force of the pull in the strongest man was found to be only 20 lb. more than the average.

The greatest effect of man's strength in raising a weight will be when the weight of the man is to that of his load as 1 : — $\div \sqrt{3}$, or nearly as 4 : 3.

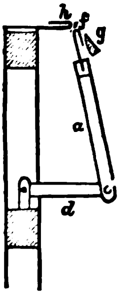
HOSIERY. The *stocking frame*, which is the great implement of this business, though it appears at first sight to be a complicated machine, consists merely of a repetition of parts easily understood, with a moderate degree of attention, provided an accurate conception is first formed of the nature of the hosiery fabric. This texture is totally different from the rectangular decussation which constitutes cloth, as the slightest inspection of a stocking will show; for this, instead of having two distinct systems of thread, like the warp and the weft, which are woven together, by crossing each other at right angles, the whole piece is composed of a single thread united or looped together in a peculiar manner, which is called stocking-stitch, and sometimes chain-work.

A single thread is formed into a number of loops or waves, by arranging it over a number of parallel needles; these are retained or kept in the form of loops or waves, by being drawn or looped through similar loops or waves formed by the thread of the preceding course of the work. The fabric thus formed by the union of a number of loops is easily unravelled, because the stability of the whole piece depends upon the ultimate fastening of the first end of the thread; and if this is undone, the loops formed by that end will open, and release the subsequent loops, one at a time, until the whole is unravelled, and drawn out into the single thread from which it was made. In the same manner, if a thread in a stocking-piece fails, or breaks at any part, or drops a stitch, as it is called, it immediately produces a hole, and the extension of the rest can only be prevented by fastening the end. It should be observed that there are many different fabrics of stocking-stitch for various kinds of ornamental hosiery, and as each requires a different kind of frame or machine to produce it, we should greatly exceed our limits to enter into a detailed description of them all. The species we have described is the common stocking-stitch used for plain hosiery, and is formed by the machine called the common stocking-frame, which is the groundwork of all the others. The operation consists in drawing the loop of a thread successively through a series of other loops, so long as the work is continued.

There is a great variety of different frames in use for producing various ornamental kinds of hosiery.

Rib stocking-frame. This frame, which, next to the common frame, is most extensively in use, is employed for working those striped or ribbed stockings, which are very common in all the different materials of which hosiery is formed. In principle it does not differ from the common frame, and not greatly in construction. The preceding general description will nearly apply to this machine with equal propriety as to the former; that part, however, by which the ribs or stripes are formed, is entirely an addition.

This frame has been already referred to for the illustration of those parts of the machinery which are common to both, and those parts therefore require no recapitulation. The principle of weaving ribbed hosiery possesses considerable affinity to that which subsists in the weaving of that kind of cloth which is distinguished by the name of tweeling, for the formation of stripes, with some variation arising merely from the different nature of the fabric. In cloth weaving, two different kinds of yarn, intersecting each other at right angles, are employed; in hosiery only one is used. In the tweeling of cloth, striped as dimity, in the cotton or kerseymere, and in the woollen manufacture, the stripes are produced by reversing these yarns. In hosiery, where only one kind of yarn is used, a similar effect is produced by reversing the loops. To effect this reversing of the loops, a second set of needles is placed upon a vertical frame, so that the bends of the hooks may be nearly under those of the common needles. These needles are cast into tin moulds, pretty similar to the former, but more oblique or bevelled towards the point, so as to prevent obstructions in working them. They are also screwed to a bar of iron, generally lighter than the other, and secured by means of plates: this bar is not fixed, but has a pivot in each end, by means of which the bar may have a kind of oscillatory motion on these pivots. The two frames of iron support this bar; that in which it oscillates being nearly vertical, but inclined a little towards the other needles. This figure, which is a profile elevation, will serve to illustrate the relative position of each bar to the other. The vertical frame at *a* is attached to the horizontal frame *d*, by two centre screws, which serve as joints for it to move in. On the top of this frame is the rib-needle bar at *f*, and one needle is represented at *f*. At *g* is a small presser, to shut the barbs of the rib-needles, in the same manner as the large one does those of the frame. At *h* is one of the frame-needles, to show the relative position of the one set to the other. The whole of the rib-bar is not fitted with needles like the other; for here needles are only placed where ribs or stripes are to be formed, the intervals being filled up with blank leads, that is to say, with sockets of the same shape as the others, but without needles; being merely designed to fill the bar and preserve the intervals. Two small handles depend from the needle-bar, by which the oscillatory motion upon the upper centres is given. The rising and sinking motion is communicated to this machine by chains which are attached to iron sliders below, and which are wrought by the hosier's heel when necessary. The pressure takes place partly by the action of the small presser, and partly by the motion of the needles in descending. A small iron slider is placed behind the rib-needles, which rises as they descend, and serves to free the loops perfectly from each other.



In the weaving of ribbed hosiery, the plain and rib courses are wrought alternately. When the plain are finished, the rib-needles are raised between the others, but no additional stuff is supplied. The rib-needles, intersecting the plain ones, merely lay hold of the last thread, and, by again bringing it through that which was on the rib-needle before, give it an additional looping, which reverses the line of chaining, and raises the rib above the plain intervals, which have only received a single knitting.

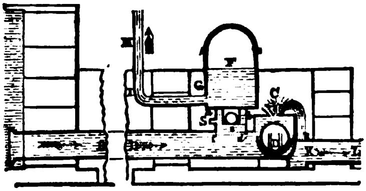
HYALITE, Manufacture of. This name is given to a black glass first made in Bohemia, in 1820, by M. de Buquoi. To prepare it, it is necessary to add to the materials for white glass, a quantity of iron forge cinder powder, charcoal dust in excess, and calcined bone powder. The forge cinder may be replaced by basalt, or lava. If sufficient charcoal is not present, the glass takes a green color. A red hyalite may be obtained with calcined bone powder, oxide of copper, carbon, &c., and all these varieties present a marbled structure upon cutting. These glasses are very beautiful: they are fit to take the place of porcelain in many cases, possess far more lustre, and can receive a more perfect polish.

HYDRARGYLLITE. A name given to the native phosphate of alumina, under the erroneous idea that it consisted of alumina and water.

HYDRATES. Compounds containing water as one of their proximate elements, and in definite proportion. Caustic potash is a *hydrate of potassa*, composed of

1 equivalent of potassa = 48, and 1 of water = 9. Slaked lime, which is an apparently dry white powder, is a *hydrate of lime*.

HYDRAULIC RAM, or WATER RAM. An ingenious hydraulic machine for raising water by means of its own impulse. The principle of its action and the mechanism of its construction may be described as follows:



The water arriving at A from the reservoir with the velocity due to the height of the fall, passes along the pipe A B, which should have an inclination of at least an inch for every two yards, escapes through an orifice C, which may be shut at pleasure by means of a valve. A reservoir, F, filled with air, is attached by means of a cylinder, *a b c d*, to the pipe A B D; in the middle of the bottom of the reservoir F is a circular orifice, to which there is adapted a short cylindrical tube, of which the extremity E is also furnished with a valve. Another valve, S, serves to supply the air to the space comprised between the cylinder *a b c d* and the tube E. G I H is an ascensional tube rising from the reservoir F. The water which escapes at C is carried off by the waste pipe K L.

The form of this apparatus (or perhaps its mode of action) suggested the name it has received. The pipe A B C is called the *body of the ram*; and the extremity, where the valves and the reservoir F are placed, is called its *head*. Both valves D and E are formed of hollow balls supported on muzzles, and of such a thickness of metal that they weigh about twice as much as the quantity of water they displace.

We may now consider the effects of the engine when in action. The water, flowing through the orifice G, acquires the velocity due to the height of the fall, and raises the ball D from its support till it comes to the orifice C; the extremity of this orifice is covered with leather, or with cloth filled with pitch, so that when the ball is applied to it, the passage of the water is effectually prevented. As soon as this orifice is closed, the water raises the ball E which had shut the orifice of the reservoir F, and a portion of it introduces itself into this reservoir, and into the pipe G I H. It thus loses the velocity which it had when the orifice C was shut, and the balls D and E fall down in consequence, the one on its support, and the other on the orifice at E. When this takes place, every thing is in the same state in which it was at first. The water begins again to flow through the orifice C; the valve D is again shut; and the same effects are repeated in an interval of time, which, for the same ram, undergoes little variation.

Every time the impulse is renewed, a quantity of water is forced up into the reservoir F and the tube H; and as it is prevented from returning by the action of the valve, it must necessarily be delivered at the extremity of H. The use of the air-vessel F is to keep up a continuous motion of the ascending column of water. The communication with the external atmosphere being cut off, the air within F is compressed by a force proportional to the height of the surface of the water in H above its surface in F; and this compressed air, acting by its elasticity on the water, maintains a continuous flow through H. The air-vessel, however, though it assists the action of the ram, is not an essential part of it; the continuity of the discharge of water may be effected by means of two or more rams, of which the ascensional pipes G I H all terminate in a single branch. On this principle works have been erected at Marly, in France, which raise water in a continuous jet to the height of 57 *metres*, or 187 English feet.

As the ascending column of water communicates with the air in the reservoir F, this would soon be exhausted if a fresh portion of air were not introduced at each stroke of the ram. The little tube S, which is stopped by a valve opening inwards, serves for this purpose. At the instant when the orifice C is closed a recoil takes place, by which the water is thrown back from the head of the ram towards the cistern; and a partial vacuum being thus produced within the cylinder *a b c d*, the pressure of the external atmosphere forces open the valve in the canal S, and a portion of air enters the cylinder, whence it is driven into the reservoir, excepting the small part of it which lodges in the space between the cylinder *a b c d* and the tube E.

The invention of the hydraulic ram,

at least in the improved form here described, belongs to Montgolfier, of Montpelier. A machine, however, on the same principle had previously been suggested, and even erected at Chester (Eng.), by Mr. Whitehurst, but much less perfect in its mode of action; for the orifice C, instead of being opened and shut by the action of the water itself, required to be opened and shut by the hand by means of a stop-cock. Owing to this circumstance, Whitehurst's machine was of little utility, and appears to have soon been entirely forgotten.

HYDRAULIC PRESSURE ENGINES. A Mr. Glynn brought under the notice of the British Association in 1849 the means of employing high falls of water to produce reciprocating motion, by means of a pressure engine; this latter acted on by the power of a descending column of water upon the piston of a cylinder to give motion to pumps for raising water to a different level, or to produce a reciprocating motion for other purposes. The pressure engine was calculated to give great mechanical effect in cases where water-falls exist of much too great a height and too small a volume to be practically used efficiently on water wheels within the ordinary limits of diameter. One of these engines is at present worked at the Allport Mines, Derbyshire. The cylinder is 50 inches diameter, and the stroke 10 feet, worked by a column of water 132 feet high, so that the proportion of power to act on it was the area of a piston to that of the plunger, namely, 1,963 to 1,385, or fully 70 per cent. The engine lever cost 60 dollars a year since its erection in 1841. Its usual speed is 5 strokes per minute, but can work 7 without any concussion in the descending column. The duty actually done being equal to 163 horse power. Area of plunge 9·621 feet × 10 ÷ 7 strokes = 673·41. 673·41 × 62·5 ÷ 132 $= \frac{5555632}{33000} =$ 163 horse power.

In this engine as in others, when water acts by its gravity or pressure, these machines do the best work when the water enters the machine without shock or impulse, and leaves it without velocity, obtaining thus all the available power that the water can yield with the least loss of effect. This result is best accomplished by making the pipes and passages of sufficient size to prevent acceleration of the hydrostatic column.

The pressure of a small column of water, as that of a common hydrant pipe, has been made to turn a coffee-mill, which it works economically and efficiently. There are many small machines which might readily be turned by the Croton water in New York, and also in other large cities by the mere descending force of the small hydrant or hose pipe. It would be in cities one of the simplest and least expensive powers.

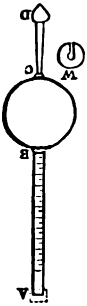
HYDRIODIC ACID. A gaseous compound of hydrogen and iodine, obtained by the mutual decomposition of iodide of phosphorus and water. It is composed of 126 iodine + 1 hydrogen; and its equivalent, therefore, is 127. The specific gravity of this gas is 4·4. One hundred cubic inches weigh 186 grains. It is rapidly absorbed by water, furnishing a sour, colorless, and dense liquid, which soon becomes brown by exposure to air, in consequence of the evolution of a little free iodine. It is instantly decomposed by chlorine, which abstracts the hydrogen to form hydrochloric (muriatic) acid, and sets the iodine free.

HYDROBROMIC ACID. A gaseous acid composed of 78 bromine + 1 hydrogen. It is obtained by the mutual decomposition of bromide of phosphorus and water.

HYDROCARBON. A term applied by chemists to compounds of hydrogen and carbon. These elements unite in several proportions, and form a variety of curious definite combinations, which are commonly called *hydrocarburets*.

HYDROCARBURETS. Compounds of hydrogen and carbon. These appear to be several definite combinations of these elements; among them the following deserve especial notice: 1. *Light carburetted hydrogen gas*, which is the *fire-damp* of coal mines and of marshes: 100 cubic inches weigh about 17·4 grains. It consists of two atoms of hydrogen = 2, and 1 of carbon = 6; its equivalent is 8. It burns with a pale blue flame. 2. *Olefiant gas*, which is formed during the distillation of equal measures of alcohol and sulphuric acid: 100 cubic inches weigh 30·5 grains. It is composed of 2 atoms of hydrogen = 2, and 2 of carbon = 12; and its equivalent, therefore, is 14. It burns with a bright white flame. Coal gas consists of a mixture of these two hydrocarbons. The term *olefiant gas* is derived from the action of chlorine upon it, which, when mixed with the gas over water, gradually condenses it into a liquid looking like oil, which is a *hydrochloride of carbon*. 3. *Quadricarburetted hydrogen*, which is produced during the destructive distillation of oil (Faraday, *An-*

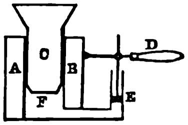
nals of Philosophy, xxvii,, 44), and which is a vapor condensable at 0°, of which 100 cubic inches weigh 61·2 grains. It consists of 4 atoms of hydrogen = 4, and 4 of carbon = 24 ; and its equivalent is 28. It burns with a dense and very smoky flame. This compound has also been called *etherine*, 1 volume of the vapor of of *ether* being constituted of 1 volume of quadrihydrocarbon and 1 of water vapor. 4. *Bicarburet of hydrogen*, obtained, like the last, from the volatile products formed during the destructive distillation of whale oil. When the quadrihydrocarbon has been distilled off from the more volatile portion, that which remains yields a product which congeals at 0°. It is a brittle white solid at that temperature : 100 cubic inches of its vapor weigh 85·3 grains, and it consists of 3 atoms of hydrogen = 3, and 6 of carbon = 36 ; its equivalent, therefore, is 39. These are the principal forms of hydrocarbon which have been satisfactorily identified : they all afford carbonic acid and water when burned in a sufficiency of oxygen ; and the proportions in which these are formed, together with the specific gravities of their respective vapors, furnish the data upon which their composition is estimated. *See* NAPTHA and NAPTHALIN.



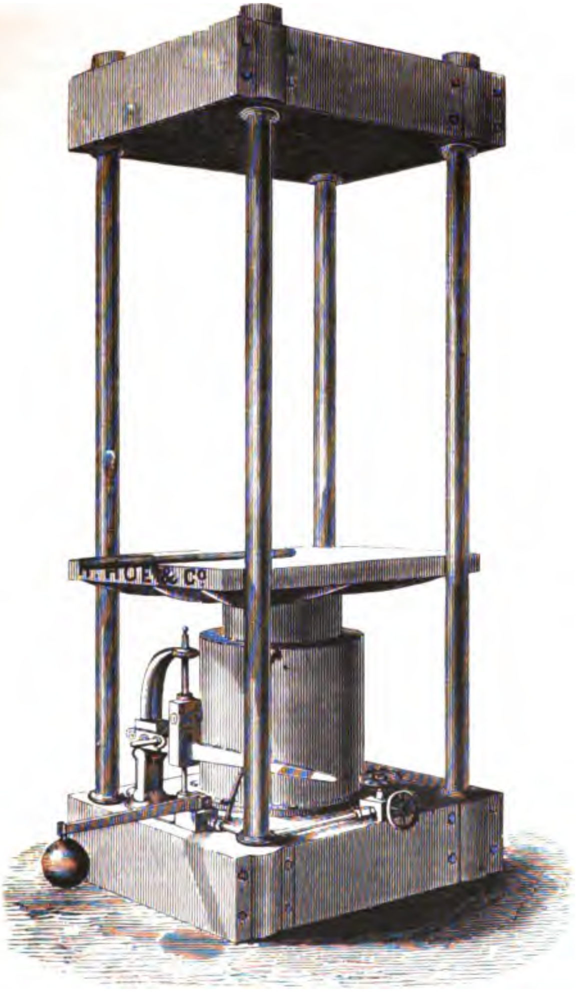
HYDROMETER. An instrument for determining the specific gravities of liquids, and thence the strengths of spirituous liquors ; these being inversely as their specific gravities. Various instruments of different forms have been proposed for ascertaining readily the specific gravities of fluids ; but as Sikes's hydrometer is directed by act of parliament to be used in collecting the revenue of Great Britain, it may be considered as more deserving of description than any of the others. This instrument is represented in the annexed figure. A B is a flat stem, divided on both sides into eleven equal parts, each of which is again subdivided into two. The stem carries a hollow brass ball B C, in which is fixed a conical stalk C D, terminating in a pear-shaped bulb D. Eight different weights of a circular form, and marked with the numbers 10, 20, 30, 40, 50, 60, 70, and 80, are cut in the manner represented at W, so that they can be placed on the stalk C D. When the strength of spirits is to be measured, one of the circular weights is placed on C D, which is found by trial to be capable of sinking the ball so far that the surface of the liquid cuts the stem at one of the divisions between A and B. The number of this division is then observed, and also the temperature of the liquid ; and the corresponding strength per cent. of the spirits is then found in a table which accompanies the instrument.

Another easy method of determining the destinies of different liquids, frequently practised, is by means of a set of glass beads previously adjusted and numbered. Thrown into any liquid, the heavier balls sink and the lighter float at the surface ; but one of them approaching the density of the liquid will be in a state of indifference as to buoyancy, or will float under the surface. The number on this ball indicates, in thousandth parts, the specific density of the liquid.

HYDROSTATIC PRESS, also called the *Hydraulic Press*, and sometimes from the name of the engineer who gave it the form under which it is now constructed, and brought it into general use, *Bramah's Press*, is a machine by means of which an enormous force of pressure is obtained through the medium of water. The principle is the same as that of the *hydrostatic bellows* ; from which, indeed, it only differs by the substitution of a strong forcing pump for the long tube, and a barrel and piston for the leather and boards. It consists of a short and very strong pump-barrel A B, with a solid piston C of proportionate strength, which is pushed upwards against the thing to be compressed, by water driven into the barrel beneath it at F from the small forcing pump E. If the small pump have only one thousandth of the area of the large barrel, and if a man, by means of its lever handle D, press its piston down with a force of five hundred pounds, the piston of the great barrel, in virtue of the hydrostatic principle of equal pressure in all directions, will riso with a force of a thousand times five hundred pounds, or more than 200 tons. The hydrostatic press is applied to a great variety of useful purposes ; for compressing bales of goods, as paper, cotton, wool, tobacco, &c., for expressing oils from seeds, raising weights, uprooting trees, &c.



HYGROMETER, or DEW-MEASURER, is an instrument for measuring the de-



HYDROSTATIC PRESS. Page 254.

grees of moisture or dryness of the atmosphere.

Variations in the state of the atmosphere with respect to moisture and dryness are manifested by a great variety of phenomena; and, accordingly, numerous contrivances have been proposed for ascertaining the amounts of those variations by referring them to some conventional scale. All such contrivances are called *hygrometers;* but though the variety of form that may be given to them, or of substances that may be employed, is endless, they may all be referred to two classes; namely, 1st, those which act on the principle of *absorption;* and, 2d, those which act on the principle of *condensation.*

1. *Hygrometers on the Principle of Absorption.*—Many substances in each of the three kingdoms of nature absorb moisture from the atmosphere with greater or less avidity, and thereby suffer some change in their dimensions, or weight, or some of their physical properties. Animal fibre is softened and relaxed, and consequently elongated, by the absorption of moisture. Cords composed of twisted vegetable substances are swollen, and thereby shortened, when penetrated by humidity; and the alternate expansion and shrinking of most kinds of wood, especially when used in cabinet-work, and after the natural sap has been evaporated, is a phenomenon with which every one is familiar. Many mineral substances absorb moisture rapidly, and thereby obtain an increase of weight. Now it is evident that any of these changes, either of dimension or of weight, may be regarded as the measure of the quantity of moisture absorbed, from which the quantity of water existing in the atmosphere in the state of vapor is inferred; but many, indeed the far greater part of them, are so small in amount, or take place so slowly, that they afford no certain indication of the actual state of the atmosphere at any particular moment.

Of the different kinds of hygrometers whose construction depends on change of dimensions, arising foom the absorption of moisture, there are two deserving of notice on account of their historical celebrity, though they are now seldom, if at all, used where accurate meteorological observations are attempted. One is the *hair* hygrometer of Saussure; the other the *whalebone* hygrometer of DeLuc.

Saussure's hygrometer consists of a human hair prepared by boiling it in a caustic ley. One extremity of the hair is fastened to a hook, or held by pincers; the other has a small weight attached to it, by which it is kept stretched. The hair is passed over a grooved wheel or pulley, the axis of which carries an index which moves over a graduated arch. Such is the essential part of the instrument, and it is easy to conceive how it acts. When the surrounding air becomes more humid, the hair absorbs an additional quantity of moisture, and is elongated; the counterpoise consequently descends, and turns the pulley, whereby the index is moved towards the one hand or the other. On the contrary, when the air becomes drier, the hair loses a part of its humidity, and is shortened. The counterpoise is consequently drawn up, and the index moves in the opposite direction. The accuracy of the indications of this instrument depends on the assumed principle that the expansion and contraction of the hair are due to moisture alone, and are not affected by temperature or other changes in the condition of the atmosphere. Experiment shows that the influence of temperature is not very great; but, after all precautions have been taken in preparing the instrument, it is found to be exceedingly irregular in its movements, and subject to great uncertainties. Besides, the substance is soon deteriorated, and will scarcely maintain its properties unimpaired during a single year.

The hygrometer of De Luc consists of a very thin slip of whalebone cut transversely or across the fibres, and stretched by means of a spring between two points. One end is fixed to a bar, while the other acts on the shorter arm of the index of a graduated scale. When the whalebone absorbs moisture it swells, and its length is increased; as it becomes dry it contracts; and the space over which the index moves by the one or the other of these effects gives the measure of the expansion or contraction, and the corresponding change in the hygometric state of the atmosphere. The action of this hygrometer appears to be more uncertain than that of Saussure.

The hygrometers which have been proposed on the principle of a change of weight arising from the absorption of moisture, are liable to still greater objections. Changes of weight may indeed be measured with greater accuracy by the common or torsion balance: but in the present case they are so small, that the particies of dust which are at all times floating in the atmosphere may produce a great alteration in the results. A great variety of substances which attract moisture have been employed, such as sponge, cotton, bibulous paper, caustic potash, the deliquescent salts, sulphuric acid, &c.; but the indications which they give are deserving of very little credit. Changes of property indicated by the torsion of cords formed of gut, hemp, cotton, &c., and the torsion of certain vegetable fibres, are still more fallacious.

2. *Hygrometers on the Principle of Condensation.*—The instruments of this class are of a far more refined nature than those which we have been describing. In order to give an idea of the general principle on which they depend, let us conceive a glass jar, having its sides perfectly clean and transparent, to be filled with water, and placed on a table in a room where the temperature is, for example, 60°, the temperature of the water being the same as that of the room. Let us next suppose pieces of ice, or a freezing mixture, to be thrown into the water, whereby the water is gradually cooled down to 55, 50, 45, &c., degrees. As the process of cooling goes on, there is a certain instant at which the jar loses its transparency, or becomes dim; and, on attentively examining the phenomenon, it is found to be caused by a very fine dew or deposition of aqueous vapor on the external surface of the vessel. The precise temperature of the water, and, consequently, of the vessel, at the instant when this deposition begins to be formed, is called the *dew point*, and is capable of being noted with great precision. Now this temperature is evidently that to which, if the air were cooled down, under the same pressure, it would be completely saturated with moisture, and ready to deposit dew on any body in the least degree colder than itself. The difference, therefore, between the temperature of the air, and the temperature of the water in the vessel when the dew begins to be formed, will afford an indication of the dryness of the air, or of its remoteness from the state of complete saturation.

But the observation which has now been described is capable of affording far more interesting and precise results than a mere indication of the comparative dryness or moisture of the atmosphere. With the help of tables of the elastic force of aqueous vapor at different temperatures, it gives the means of determining the absolute weight of the aqueous vapor diffused through any given volume of air, the proportion of vapor existing in that volume to the quantity that would be required to saturate it, and of measuring the force and amount of evaporation.

The elastic force of aqueous vapor at the boiling point of water is evidently equal to the pressure of the atmosphere. This may be assumed as corresponding to a column of mercury 30 inches in height. Mr. Dalton, in the fifth volume of the *Manchester Memoirs*, has given the details of a most valuable and beautiful set of experiments, by which he ascertained the elastic force of vapor from water at every degree between its freezing and boiling points in terms of the column of mercury which it is capable of supporting. As the same experiments have since been frequently repeated, and the different results present all the accordance which can be expected in so delicate an investigation, the tension of vapor at the different temperatures may be regarded as sufficiently well determined. Supposing, then, we have a table exhibiting the elasticity or tension corresponding to every degree of the thermometer, the weight of a given volume of vapor, for example a cubic foot, may be determined as follows:

Steam at 212°, and under a pressure of 30 inches of mercury, is 1700 times lighter than an equal bulk of water at its greatest density, or a temperature of about 40°, and a cubic foot of water at that temperature weighs 437272 grains; the weight, therefore, of a cubic foot of steam at that temperature and pressure is 437272÷1700=257·218 grains. Hence we may find the weight of an equal bulk of vapor of the same temperature under any other given pressure, suppose 0·56 of an inch; for the density being directly as the pressure, we have 30 in. : 0·56 in. : : 257·218 grs. : 4·801 grs., which is the weight required.

Having found the weight of a cubic foot of vapor under a pressure of 0·56 of an inch, and at the temperature 212°, we may find its weight under the same pressure at any other temperature, suppose 60°. It is ascertained by experiment that all aeriform bodies, whether vapors or gases, expand the 1-480th part of their volume for every accession of temperature equivalent to one degree of Fahrenheit's scale; therefore, reckoning a volume of gas at 32° as unity, its volume at 60° is to its volume at 212° as $1 + \frac{28}{480}$ is to $1 + \frac{180}{480}$; or as 1·058 : 1·375; and the density and weight being inversely as the volume, we have

1·058 : 1·375 : : 4·801 grs. : 6·222 grs.

for the weight of a cubic foot of vapor at temperature 60°, and under a pressure of 0·56 of an inch of the mercurial column.

The following table, abridged from *Daniell's Meteorological Essays*, shows the force of tension, weight, and expansion of aqueous vapor, at different temperatures, on Fahrenheit's scale.

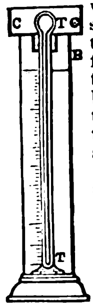
Temp.	Force.	Weight of a cubic foot.	Expansion.
0	·068	·856	·9334
5	·083	1·034	·9438
10	·098	1·208	·9542
15	·119	1·451	·9646
20	·140	1·688	·9750
25	·170	2·028	·9855
30	·200	2·361	·9959
35	·240	2.805	1·0063
40	·280	3·239	1·0167
45	·340	3·898	1·0271
50	·400	4·535	1·0375
55	·476	5·342	1·0479
60	·560	6·222	1·0583
65	·657	7·230	1·0687
70	·770	8·392	1·0791
75	·906	9·780	1·0895
80	1·060	11·333	1·0999
85	1·235	13·081	1·1003
90	1·430	15·005	1·1107
95	1·636	17·009	1·1211
212	30·000	257·218	20·6005

Having thus explained the principle of the common hygrometer, we will now describe one or two of the forms under which it has been most frequently constructed. Daniell's hygrometer consists of two thin glass balls of 1½ inch diameter, connected together by a tube having a bore about ⅛th of an inch. The tube is bent at right angles over the two balls, and the arm contains a small thermometer whose bulb, which should be of a lengthened form, descends into the ball. This ball, having been about two thirds filled with ether, is heated over a lamp till the fluid boils, and the vapor issues from the capillary tube which terminates the ball. The vapor having expelled the air from both balls, the capillary tube is hermetically closed by the flame of a lamp. The other ball is to be covered with a piece of muslin. The stand is of brass, and the transverse socket is made to hold the glass tube in the manner of a spring, allowing it to turn and be taken out with little difficulty. A small thermometer is inserted into the pillar of the stand. The manner of using the instrument is this: after having driven out all the ether into the ball by the heat of the hand, it is to be placed at an open window, or out of doors, with the ball so situated that the surface of the liquid may be on a level with the eye of the observer. A little ether is then to be dropped on the covered ball. Evaporation immediately takes place, which producing cold upon the covered ball causes a rapid continuous condensation of the ethereal vapor in the interior of the instrument. The consequent evaporation from the included ether produces a depression of temperature in the ball, the degree of which is measured by the thermometer. This action is almost instantaneous, and the thermometer begins to fall in two seconds after the ether has been dropped. A depression of 30 to 40 degrees is easily produced, and the ether is sometimes observed to boil and the thermometer to be driven below zero of Fahrenheit's scale. The artificial cold thus produced causes a condensation of the atmospheric vapor upon the uncovered ball, which first makes its appearance in a thin ring of dew coincident with the surface of the ether. The degree at which this takes place must be carefully noted. In very damp or windy weather the ether should be very slowly dropped upon the ball, otherwise the descent of the thermometer will be so rapid as to render it extremely difficult to be certain of the degree. In dry weather, on the contrary, the ball requires to be well wetted more than once, to produce the requisite degree of cold.

The instrument which has now been described is extremely beautiful in principle; but it may be doubted whether, even when the greatest caution is observed, the temperature which it indicates is precisely that at which the deposition of dew takes place. The deposition first occurs in a narrow ring on a level with the surface of the ether in the ball *b*, thereby indicating that the ether is colder at the surface than a little under it. But if the temperature is not uniform throughout the ball, it is evident that only a small part of the bulb of the thermometer can be placed in the point where the greatest cold exists; consequently the temperature indicated by the thermometer will be greater than is necessary for producing the deposition of moisture: in other words the dew point will be given too high.

Various attempts have been made to obviate the defects of Daniell's hygrometer, but hitherto without much success. The apparatus proposed by Pouillet may be described as follows: A small cup C

C, formed of gold, and extremely thin, is fixed to a little collar of ivory B B, supported on a stand. The stem of an inverted thermometer T T descends through a perforation in the bottom of the cup, and is fitted closely into it and sealed, the ball of the thermometer being placed at the centre of the cup. In order to prevent the mercury from separating, a small portion of the air is left in the stem. When an observation is to be made, sulphuric ether is poured into the cup; and in consequence of the rapid evaporation which takes place, a considerable degree of cold is produced, and deposition takes place on the outside of the cup. The degree of the thermometer at the instant the brightness of the metal begins to be dimmed gives the dew point. The correctness of the indication depends on the identity of temperature of the ether, the metal of the cup, and the thermometer. Bright gold is found to answer the purpose better than any other metal.



As the hygrometer is one of the principal instruments in meteorological researches, its theory and the best form of its construction have been the subject of frequent discussion in the various scientific journals.

HYGROMETRIC. This term is commonly applied to substances which readily become moist and dry with corresponding changes in the state of the atmosphere, or which readily absorb and retain moisture. Sea-weed, several saline substances, porous clays, potash and its carbonate, chloride of calcium, sulphuric acid, are in this sense of the term said to be hygrometric.

HYGROMETRIC REGISTER. At one of Lord Rosse's recent scientific soirees, in London, Mr. Appold exhibited his curious Register Hygrometer for keeping the atmosphere of the house at one regular moisture. The instrument with a variation at one degree in the moisture of the atmosphere opens a valve capable of supplying ten quarts of water per hour; delivering it to pipes covered with blotting paper heated by a gas stove, by which the water is evaporated until the atmosphere is sufficiently saturated and the valve thereby closed. A lead pencil is attached to register the distance the hygrometer travels; and thus a sheet of paper moved by clock-work shows the difference between the wet and dry bulbs of the thermometer at any period of time.

HYPOSULPHITE OF SODA. This salt, so extensively used in the practice of *Daguerrotyping*, may be easily prepared in quantities by the following process:—Mix one pound of finely pulverized ignited carbonate of soda with ten ounces of flowers of sulphur, and heat the mixture slowly in a porcelain dish till the sulphur melts. Stir the fused mass, so as to expose all its parts freely to the atmosphere, whereby it passes from the state of a sulphuret, by the absorption of atmospherical oxygen, into that of a sulphite, with the phenomenon of very slight incandescence. Dissolve in water, filter the solution, and boil it immediately along with flowers of sulphur. The filtered concentrated saline liquid will afford, on cooling, a large quantity of pure and beautiful crystals of hyposulphite of soda.

IMPERMEABLE, is the epithet given to any kind of textile fabric, rendered water-proof by one or other of the following substances:—

1. Linseed oil to which a drying quality has been communicated by boiling with litharge or sugar of lead, &c.

2. The same oil holding in solution a little caoutchouc.

3. A varnish made by dissolving caoutchouc in rectified petroleum or naptha, applied between two surfaces of cloth, as described under Mackintosh's patent. See CAOUTCHOUC.

4. Vegetable or mineral pitch, applied hot with a brush, as in making tarpawling for covering goods in ships.

5. A solution of soap worked into cloth, and decomposed in it by the action of a solution of alum; whence results a mixture of acid fats and alumina, which insinuates itself among all the woolly filaments, fills their interstices, and prevents the passage of water.

6. A solution of glue or isinglass, introduced into a stuff, and then acted upon by a solution of galls or tannin when an insoluble leather is deposited in the stuff.

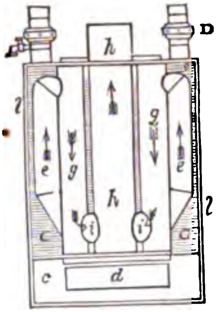
INCOMBUSTIBLE CLOTH is a tissue of the fibrous mineral called amianthus or asbestos. This is too rare to form the object of any considerable manufacture. Cotton and linen cloth may be best rendered incapable of taking fire, or burning with flame, by being imbued with a solution of sal ammoniac or phosphate of magnesia.

INCUBATION, ARTIFICIAL. The

Egyptians have from time immemorial been accustomed to hatch eggs by artificial warmth, without the aid of hens, in peculiar stoves, called *Mammals*. The inhabitants of the village Bermé still travel through the most distant provinces of Egypt at certain seasons of the year, with a portable furnace, heated by a lamp, and either hatch chickens for sale, or undertake to hatch the eggs belonging to the natives at a certain rate per dozen. M. de Reaumur published in France, about a century ago, some ingenious observations upon this subject; but M. Bonnemain was the first person who studied with due attention all the circumstances of artificial incubation, and mounted the process successfully upon the commercial scale. So far back as 1777 he communicated to the Academy of Sciences an interesting fact, which he had noticed, upon the mechanism employed by chicks to break their shells; and for some time prior to the French revolution he furnished the Parisian market with excellent poultry at a period of the year when farmers had ceased to supply it. His establishment was ruined at that disastrous era, and no other has ever since been constructed or conducted with similar care. There can be no doubt however of the practicability and profitableness of the scheme, when judiciously managed. Some imitations of his plans have been made in England, but how far they have succeeded, in an economical point of view, it is difficult to determine. His apparatus derives peculiar interest from the fact that it was founded upon the principle of the circulation of hot water, by the intestine motions of its particles, in a returning series of connected pipes; a subject afterwards illustrated in the experimental researches of Count Rumford. It has of late years been introduced as a *novelty*, and applied to warm the apartments of many public and private buildings. They were then publicly exhibited at his residence in Paris, and were afterwards communicated to the world at large in the interesting article of the *Dictionnaire Technologique*, entitled *Incubation Artificielle*.

The apparatus of M. Bonnemain consisted, 1. of a boiler and pipes for the circulation of water; 2. of a regulator calculated to maintain an equable temperature; 3. of a stove-apartment, heated constantly to the degree best fitted for incubation, which he called the *hatching* pitch. He attached to one side a *poussinière* or chick-room, for cherishing the chickens during a few days after incubation.

The boiler is represented in vertical section. It is composed of a double cylinder of copper or cast-iron, *l l*, having a grate, *b* (see plan), an ashpit at *d*. The water occupies the shaded space, c, c. *h*, *g*, *g*, *e*, *e*, are five vertical flues, for conducting the burnt air and smoke, which first rise in the two exterior flues, *e*, *e*, then descend in the two adjoining flues *g*, *g*, and finally re-mount through the passages *i*, *i*, in the central flue *h*. During this upwards and downwards circulation, as shown by the arrows in the section, the products of combustion are made to impart nearly the whole of their heat to the water by which they are surrounded. At the commencement, some burning paper or wood shavings are inserted at the orifice *m*, to establish a draught in this circuitous chimney. The air is admitted into the ashpit at the side, in regulated quantities, through a small square door, moveable round a rod which runs horizontally along its middle line. The swing valve is acted upon by an expanding bar, which opens it more or less, according to the temperature of the stove apartment in which the eggs are placed.



D is the upper orifice of the boiler, by which the hotter and consequently lighter particles of the water continually ascend, and are replaced by the cooled particles, which enter the boiler near its bottom.

When it is wished to hatch eggs with this apparatus, the fire is kindled, and when the temperature is 100°, the eggs are introduced: only one twentieth of the whole number on the first day; next day a like number is laid in the trays, and thus in succession for twenty days, so that at the end of this time those first placed will be hatched, and daily afterwards an equal number of chicks may be obtained. While thus hatching, a little of the water of the shell is evaporated and replaced by air, which becomes needful for respiration. After the chicks are hatched, they are transferred to the chick-room, which contains a small vessel filled with millet seed for the support of the chicks.

To supply an establishment of the common kind, where 100 eggs are daily hatched, a dozen hens would be needed, and 150 eggs must be placed under them, as only two-thirds succeed; at this rate 4300 mothers would be required to sit.

In China the process is different. There the hatching house is a long shed with mud walls and thickly thatched with straw. Along the ends and down one side of the building are a number of round straw baskets, well plastered with mud, to prevent them from taking fire. In the bottom of each basket there is a tile placed; or rather the tile forms the bottom of the basket. Upon this the fire acts—a small fireplace being below each basket. Upon the top of each basket there is a straw cover which fits closely, and is kept shut while the process is going on. In the centre of the shed are a number of large shelves placed one above another, upon which the eggs are laid at a certain stage of the process. When the eggs are bought they are put into the baskets—the fire is lighted below them—and a uniform heat kept up, ranging from 95 to 102 degrees; but the Chinamen regulate the heat by their own feelings, and therefore it will, of course, vary considerable. In four or five days after the eggs have been subject to this temperature, they are taken carefully out, one by one, to a door, in which a number of holes have been bored nearly the size of the eggs; they are then held against these holes, and the Chinamen look through them, and are able to tell whether they are good or not. If good, they are taken back, and replaced in their former quarters; if bad, they are, of course, excluded. In nine or ten days after this—that is, about fourteen days from commencement—the eggs are taken from the basket, and spread out on the shelves. Here no fire-heat is applied, but they are covered over with cotton, and a kind of blanket, under which they remain about fourteen days more, when the young ducks burst their shells, and the shed teems with life. These shelves are large and capable of holding many thousands of eggs; and when the hatching takes place, the sight is not a little curious. The natives who rear the young duck in the surrounding country know exactly the day when it will be ready for removal; and in two days after the shell is burst, the whole of the little creatures are sold and conveyed to their new quarters.

INDIGO. From the differences which exist in the nature and culture of the *indigofera*, and of its treatment by the manufacturer, the product, *indigo*, as found in commerce, differs remarkably in quality and chemical composition. Besides the impurities accidentally present, from a bad season, want of skill or care, the purest commercial indigo consists of no less than five constituents—1. *Indigo-blue*, a very singular vegetable compound of carbon, hydrogen, and oxygen, with about ten per cent. of azote; 2. *Indigo-gluten*, a yellow, or brownish-yellow varnish, which differs from wheat-gluten by its solubility in water. It has the taste of osmazome, or of beef-soup, melts when heated, burns with flame, and affords an empyreumatic oil along with ammonia by distillation; 3. *Indigo-brown*. This constituent is more abundant than the preceding. It is extracted by a concentrated water of potash, made to act on powdered indigo, previously digested in dilute sulphuric acid. Chevreuil's indigo-green seems to have consisted of this substance, mixed with some alkaline matter, and indigo-blue; 4. *Indigo-red*. This is readily dissolved by boiling alcohol out of indigo previously subjected to the action of an acid or alkaline menstruum. The alcohol acquires a beautiful red tinge, and leaves by its evaporation the red principle in the form of a blackish-brown varnish; 5. *Phosphate of lime*. Dr. Ure found the bone phosphate in notable quantity in some fine indigo, constituting another feature of resemblance between this vegetable and animal products. Hence, also, the charcoal of indigo is most difficult of incineration, and requires, for perfect combustion, in some cases, the deflagratory powers of nitric acid.

The species of *indigofera* are leguminous plants, herbaceous or shrubby. They are very numerous in the equatorial regions of the globe. The *I. tinctoria* is the species most abundantly cultivated. The plant requires a rich, light soil, and a warm exposure. It succeeds best on newly-cleared lands, on account of their moisture; it requires protection against high winds, and needs irrigation in times of drought. The ground, after being properly prepared for the reception of the seed by ploughing, is sown pretty thickly, the time of sowing being so chosen that rain may fall upon the plant as soon as it shows itself above the ground, by which it is not only greatly invigorated, but cleansed from innumerable insects.

As the plant approaches to maturity, the leaves undergo a sudden change in color, from a light to a dark green. As soon as this change is observed, the branches are severed from the parent stem early in the morning, and spread out in the sun till the afternoon, by which time they become sufficiently dry to be beaten from the branches by a stick. The leaves, so separated, are housed in warehouses, closely packed and well trodden down by natives.

The plants, from which leaves have been severed, send forth a new crop, which is gathered, when mature, like the first. The cuttings, in a favorable season, are repeated three or four times, after which the ground is ploughed up for another sowing; but each successive growth of the branches produces an increased deterioration of the qualities of the leaves, so that one part of the leaves of the first cutting yields as much indigo as two parts of the third crop. The dried leaves are not immediately used, but are kept packed for one month, during which time they suffer a material change, which is indicated by their having passed to a light lead color. By additional keeping, the lead color gradually darkens, until it becomes black. The maximum quantity of indigo is to be obtained when the lead color is attended with a loss in the quantity of the indigo. The dried leaves, after having suffered the change of color, are transferred to the steeping-vat (an uncovered reservoir, 80 feet square, and 26 inches deep, constructed of brick, and lined with stucco,) where they are mingled with water, in the proportion of about one volume of leaves to six of water, and allowed to remain two hours.

The great affinity of indigo for oxygen is very manifest, in the quick change of the color of the leaves which float on the surface, and are exposed to the action of the atmosphere, to a blackish blue, when contrasted with those below, which remain unchanged. On this account, the vat is frequently stirred, so that the floating leaves may be immersed. After two hours' infusion, the water, which, from the solution of imperfectly-oxygenized indigo, has acquired a fine green color, is allowed to run off from the leaves, through strainers, into the beating-vat, where it is agitated by the paddles of 10 or 12 natives for about two hours, during which time the fine green liquor gradually darkens to a blackish-blue. At this time, lime-water is thrown into the vat, and thoroughly agitated with the whole mass of fluid. The mass is then left to subside for the space of three hours, when the supernatant liquid, which is of a fine bright Madeira color, is withdrawn, by orifices in the vat at different heights. The indigo is then removed to the covered part of the manufactory, where it is put on a straining-cloth, and allowed to drain throughout the night. On the following morning it is transferred to a copper boiler, where it is mingled with a quantity of water, and raised to ebullition. The contents of the copper are retaken to the strainers, and the drained indigo is then divided into small portions, and each portion well worked by the hands of the natives, in order to free it from air-bubbles. It is then carried to the pressing-boxes, which are usually square, and of sufficient depth to leave the cake about two inches and a quarter in thickness. By means of a powerful screw, the water is separated from the indigo; the cakes are gradually dried in the shade, and thus rendered fit for exportation.

When indigo, suspended in water, is brought into contact with certain deoxidizing agents, it is deprived of a part of its oxygen, becomes green, and is rendered soluble in water, and still more so in the alkalies. It recovers its former color, however, on exposure to the air, by again absorbing oxygen of 1-7th or 1-8th of the whole weight of the resulting indigo. Its deoxidizement is effected either by allowing it to ferment along with bran, or other vegetable matter, or by decomposing in contact with it the protosulphate of iron, by the addition of lime.

Substances dyed by deoxidized indigo receive a green tint at first, which becomes blue by exposure to the air. This is the usual method of coloring cloths by means of indigo, which, when fully oxidized, affords a permanent dye, not removable by soap or by acids.

Indigo, purified by sublimation, is composed of 73·26 carbon, 13·81 nitrogen, 10·43 oxygen, and 2·5 hydrogen.

Employment of indigo in dyeing.—As indigo is insoluble in water, and as it can penetrate the fibres of wool, cotton, silk, and flax, only when in a state of solution, the dyer must study to bring it into this condition in the most complete and economical manner. This is effected either by exposing it to the action of bodies which have an affinity for oxygen superior to its own, such as certain metals and metallic oxydes, or by mixing it with fermenting matters, or, finally, by dissolving it in a strong acid, such as the sulphuric. The second of the above methods is called the warm hue, or pastel vat; and being the most intricate, we shall begin with it.

Before the substance indigo was known in Europe, woad having been used for dyeing blue, gave the name of woad vats to the apparatus. The vats are sometimes made of copper, at other times of iron or wood, the last alone being well adapted for the employment of steam. The dimensions are very variable; but the following may be considered as the average size: depth, 7½ feet; width below, 4 feet; above, 5 feet. The vats are built in such a way that the fire does not affect their bottom, but merely their sides half way up; and they are sunk so much under the floor of the dyehouse, that their upper half only is above it, and is surrounded with a mass of masonry to prevent the dissipation of the heat. About 3 or 3½ feet under the top edge an iron ring is fixed, called the *champagne* by the French, to which a net is attached in order to suspend the stuffs out of contact of the sediment near the bottom.

In mounting the vat the following articles are required: 1. woad prepared by fermentation, or woad merely dried, which is better, because it may be made to ferment in the vat, without the risk of becoming putrid, as the former is apt to do; 2. indigo, previously ground in a proper mill; 3. madder; 4. potash; 5. slaked quicklime; 6. bran. In France, weld is commonly used instead of potash.

The vat being filled with clear river water, the fire is to be kindled, the ingredients introduced, and if fermented woad be employed, less lime is needed than with the merely dried plant. Meanwhile the water is to be heated to the temperature of 160° Fahr., and maintained at this pitch till the deoxidizement and solution of the indigo begin to show themselves, which, according to the state of the constituents, may happen in 12 hours, or not till after several days. The first characters of incipient solution are blue bubbles, called the flowers, which rise upon the surface, and remain like a head of soap-suds for a considerable time before they fall; then blue coppery shining veins appear with a like colored froth. The hue of the liquor now passes from blue to green, and an ammoniacal odor begins to be exhaled. Whenever the indigo is completely dissolved, an acetic smelling acid may be recognised in the vat, which neutralizes all the alkali, and may occasion even an acid excess, which should be saturated with quicklime. The time for doing this cannot be in general very exactly defined. When quicklime has been added at the beginning in sufficient quantity, the liquor appears of a pale wine-yellow color, but if not, it acquires this tint on the subsequent introduction of the lime. Experience has not hitherto decided in favor of the one practice or the other.

As soon as this yellow color is formed in the liquor, and its surface becomes blue, the vat is ready for the dyer, and the more lime it takes up without being alkaline, the better is its condition. The dyeing power of the vat may be kept up during six months, or more, according to the fermentable property of the woad. From time to time, madder and bran must be added to it, to revive the fermentation of the sediment, along with some indigo and potash, to replace what may have been abstracted in the progress of dyeing. The quantity of indigo must be proportional, of course, to the depth or lightness of the tints required.

Cold vats.—The *copperas* or *common blue vat* is so named because the indigo is reduced by means of the protoxide of iron. This salt should therefore be as free as possible from the red oxide, and especially from any sulphate of copper, which would re-oxidize the indigo. The necessary ingredients are: copperas (green sulphate of iron), newly slaked quicklime, finely ground indigo, and water; to which sometimes a little potash or soda is added, with a proportional diminution of the lime. The operation is conducted in the following way: the indigo, well triturated with water or an alkaline ley, must be mixed with hot water in the *preparation* vat, then the requisite quantity of lime is added, after which the solution of copperas must be poured in with stirring. Of this *preparation* vat, such a portion as may be wanted is laded into the dyeing vat. For one pound of indigo three pounds of copperas are taken, and four pounds of lime (or 1 of indigo, 2½ of copperas, and 3 of lime). If the copperas be partially peroxidized, somewhat more of it must be used.

A vat containing a considerable excess of lime is called a *sharp* vat, and is not well adapted for dyeing. A *soft* vat, on the contrary, is that which contains too much copperas. In this case the precipitate is apt to rise, and to prevent uniformity of tint in the dyed goods. The sediment of the copperas vat consists of sulphate of lime, oxide of iron, lime with indigo brown, and lime with indigo blue, when too much quicklime has been employed. The clear, dark wine yellow fluid contains indigo blue in a reduced state, and indigo red, both combined with lime and with the gluten of indigo dissolved. After using it for some time the vat should be refreshed or fed with copperas and lime, upon which occasion the sediment must first be stirred up, and then allowed time to settle again and become clear. For obtaining a series of blue tints, a series of vats of different strengths is required.

Linen and cotton yarn, before being dyed, should be boiled with a weak alkaline ley, then put upon frames or tied up in hanks, and after removing the froth from the vat, plunged into and moved gently through it. For pale-blues, an old, nearly exhausted vat is used; but for deep ones, a fresh, nearly saturated vat. Cloth is stretched upon a proper square dipping-frame made of wood, or preferably of iron, furnished with sharp hooks or points of attachment. These frames are suspended by cords over a pulley, and thus immersed and lifted out alternately at proper intervals. In the course of 8 or 10 minutes, the cloth is sufficiently saturated with the solution of indigo, after which it is raised and suspended so as to drain into the vat. The number of dippings determines the depth of the shade; after the last, the goods are allowed to dry, taken off the frame, plunged into a sour bath of very dilute sulphuric or muriatic acid, to remove the adhering lime, and then well rinsed in running water.

The mode of making the China blue-dye has been described under Calico Printing.

A blue dye may likewise be given by a solution of indigo in sulphuric acid. This process was discovered by Barth, at Grossenhayn, in Saxony, about the year 1740, and is hence called the Saxon blue-dye. The chemical nature of this process has been already fully explained. If the smoking sulphuric acid be employed, from 4 to 5 parts are sufficient for 1 of indigo; but if oil of vitriol, from 7 to 8 parts. The acid is to be poured into an earthenware pan, which in summer must be placed in a tub of cold water, to prevent it getting hot, and the indigo, in fine power, is to be added, with careful stirring, in small successive portions. If it becomes heated, a part of the indigo is decomposed, with the disengagement of sulphurous acid gas, and indigo-green is produced. Whenever all the indigo has been dissolved, the vessel must be covered up, allowed to stand for 48 hours, and then diluted with twice its weight of clear river water.

The acidulated mass has a black color, is opaque, thick, attracts water from the air, and is called *indigo composition*, or *chemic-blue*. It must be prepared beforehand, and kept in store. In this solution, besides the *cerulin*, there are also indigo-red, indigo-brown, and gluten, by which admixture the pure blue of the dye is rendered foul, assuming a brown or a green cast. To remove these contaminations, wool is had recourse to. This is plunged into the indigo previously diffused through a considerable body of water, brought to a boiling heat in a copper kettle, and then allowed to macerate as it cools for 24 hours. The wool takes a dark-blue dye by absorbing the indigo-blue sulphate and hyposulphite, while at the same time the liquor becomes greenish-blue; and if the wool be left longer immersed, it becomes of a dirty-yellow. It must therefore be taken out, drained, washed in running water till this runs off colorless, and without an acid taste. It must next be put into a copper full of water, containing one or two per cent. of carbonate of potash, soda, or ammonia (to about one-third the weight of the indigo), and subjected to a boiling heat for a quarter of an hour. The blue salts forsake the wool, leaving it of a dirty red-brown, and dye the water blue. The wool is in fact dyed with the indigo-red, which is hardly soluble in alkali. The blue liquor may now be employed as a fine dye, possessed of superior tone and lustre. It is called distilled blue and *soluble blue*. Sulphuric acid throws down from it the small quantity of indigo-red which had been held in solution by the alkali.

When wool is to be dyed with this sulphate of indigo-blue, it must be first boiled in alum, then treated with blue liquor, and thus several times alternately, in order to produce a uniform blue color. Too long continuance of boiling is injurious to the beauty of the dye. In this operation the woollen fibres get impregnated with the indigo-blue sulphate of alumina.

With sulphate of indigo, not only blues

of every shade are dyed, but also green, olive, gray, as also a fast ground to logwood-blues; for the latter purpose the preparatory boil is given with alum, tartar, sulphates of copper and iron, and the blue solution; after which the goods are dyed up with a logwood bath containing a little potash.

INK. The colored liquid used for writing, is made usually by the action of the tannin of vegetable substances upon salts of iron. In the case of black ink, nut-galls, sulphate of iron, and gum, are the only substances necessary: others being added to modify the shade, or diminish the cost. Those which contain most gallic acid or tannin acid are most valuable, and the reverse. To make 12 gallons of ink, Dr. Ure directs to take

12 lbs. of Nut-galls,
5 lbs. of Green Sulphate Iron,
5 lbs. of Gum Senegal,
12 gallons of Water.

The nut-galls and water are put into a copper and well boiled, replacing the water lost: it is then poured into a tub, let to settle, and strained. The gum is then dissolved, strained, and added to the gall liquor. The copperas is also dissolved and added, when the whole becomes gradually black. It should be bottled before it attains its full blackness. A few bruised cloves added in, prevents mouldiness. Sumach, logwood, and oak-bark, are often used instead of galls, or in addition to it, to diminish the cost of manufacture; but the ink is deteriorated by their use. Logwood requires less copperas than galls. The foregoing ink is much stronger than that commonly sold, and it may be diluted with an equal quantity of water to form an ink of similar strength to that usually sold. A good black ink should write pale and become black afterwards in the paper: that which writes black at once and shines on the surface of the paper, easily rubs off and is not as permanent.

Japan ink, as such is called, is not lasting.

Inks are of almost every shade, and generally are solutions of chemical salts.

Red ink. Take a strong decoction of Brazil wood and a little gum-water, and add some alum with a few drops of the chloride of tin.

A still better red ink is a decoction of cochineal, to which a little water of ammonia has been added: or an extemporaneous red ink may be made by rubbing up carmine in strong water of ammonia, diluting the solution down to the desired shade, and adding mucilage.

Green ink. Dissolve distilled verdigris is strong vinegar, and make into a proper consistency for writing with a solution of gum arabic: or boil 2 parts of verdigris, 8 parts of water, and 1 part of cream of tartar together down to one half, let settle, strain, and bottle.

Yellow ink. A little alum added to saffron and water, makes a very good yellow ink—thicken with gum: or boil 8 parts of alum, 100 parts of water, and 25 parts of Persian berries together, strain, and add mucilage; or dissolve gamboge in water.

The different dye-stuffs and solutions, afford inks of any desired shade.

Mr. I. Deck has recommended a new mode of making black ink, which affords a good color and is remarkably cheap. The process is this: boil 1 part of logwood in 100 parts of water until the liquor is pretty strong, and to one quart of it put in one quarter of an ounce of chromate of potash, and set it apart, shaking it frequently, for about three weeks. At first the appearance of the ink will be a little greenish, but after it is exposed to the sun and air for some time, it gets beautiful, is very fast, and does not injure steel pens.

Ink powder. Blue galls, 2 ounces; gum arabic, ½ an ounce; sulphate of iron, 8 ounces—all powdered and well mixed together.

Indelible inks. These used to have for a basis nitrate of silver, which, in a strong solution, thickened with gum and colored, was laid with a pen on the cloth previously soaked with carbonate of soda—which reduced the oxide of silver in the tissue of the stuff. More recently, the nitrate of silver has been dissolved in water of ammonia and laid on the cloth without any further treatment: this ink is not now indelible, its stain is removed by chlorine and water of ammonia, and of course it does not resist the bleaching-powder used in laundries. Fine gold-powder, rubbed up with genuine China ink, resists the action of chlorine, oxalic acid, and washing off with water. Charcoal, rubbed up with acetic acid and thickened, furnishes a very permanent ink.

The following indestructible ink has been tried and recommended: shell lac, 2 ounces; borax, 1 ounce; distilled or rain water, 18 ounces—boil the whole in a closely-covered tin vessel, stirring it occasionally with a glass rod or a small stick, until the mixture has become homogeneous; filter, when cold, through a single sheet of blotting paper; mix the filtered solution, which will be about 19 fluid ounces, with 1 ounce of mucilage of gum arabic, prepared by dissolving 1 ounce of water, and add pulverized indigo and lamp-black, ad libitum. Boil the whole again in a covered vessel, and stir the fluid well to effect the complete solution and admixture of the gum arabic; stir it occasionally while it is cooling; and after it has remained undisturbed for two or three hours, that the excess of indigo and lamp-black may subside, bottle it for use. The above ink, for documentary purposes, is invaluable, being, under all ordinary circumstances, indestructible: it is also particularly well adapted for the use of the laboratory. Five drops of kreosote added to a pint of ordinary ink will effectually prevent its becoming mouldy.

Vanadate of ammonia treated with galls affords a good and permanent black which flows freely from the pen, it resists the action of chlorine and is not obliterated by acids or alkalies. Whenever the metal vanadium will be found more plentiful this combination will form the best ink. Perhaps the Lake Superior copper may have its vanadium turned to advantage in this way.

Ink for Lithographers.—White soap 25 parts, white wax 25 parts, mutton suet 6 parts, lamp black 6 parts, shellac 10 parts, mastic 10 parts; mix with heat and proceed as for lithographic ink.

Sympathetic Ink.—The best is a solution of muriate of cobalt.

Copying Ink.—Gum arabic 240 grains, Spanish liquorice 20 grains, water 720 grains, dissolve; then add the solution gradually in a mortar to 60 grains of lampblack previously moistened with a teaspoonful of sherry; when well mixed strain through coarse muslin.

Saxon Blue Ink, is a solution of sulphate of indigo, used by dyers, weakened down to proper tint. A better kind of blue ink is made by rubbing together ½ oz. of best Prussian blue, (that recently made is best), oxalic acid 2 drachms, and 1 pint of water; filter, when well mixed. This has a beautiful tint.

Printer's Ink. See under that head.

INULINE, is a substance first extracted from the root of the *Inula-Hellenium*, or Elecampane. It is white and pulverulent like starch; and differs from this substance chiefly because its solution, when it cools, lets fall the inuline unchanged in powder, whereas starch remains dissolved in the cold, as a jelly or paste.

Inuline is obtained by boiling the root sliced in 3 or 4 times its weight of water, and setting the strained decoction aside till it cools, when the pulverulent inuline precipitates. It exists also in the roots of colchicum and pellitory.

IODINE, is one of the simple chemical bodies which was discovered accidentally in 1812, by M. Courtois, a manufacturer of saltpetre, in the mother-waters of that salt. Its affinities for other substances are so powerful as to prevent it from existing in an insulated state. It occurs combined with potassium and sodium in many mineral waters, such as the brine spring of Ashby-de-la-Zouche, and other strongly saline springs. This combination exists sparingly in sea-water, abundantly in many species of *fucus* or seaweed, and in the kelp made from them; in sponges; in several marine *molluscæ*, such as the *doris*, the *venus*, oysters, &c.; in several polyparies and sea-plants, as the *gorgonia*, the *zostera marina*, &c.; particularly in the mother-waters of the salt-works upon the Mediterranean sea; and it has been found in combination with silver, in some ores brought from the neighborhood of Mexico.

It is an ingredient in the salt licks, saline, and brine springs of this country, especially of those in the Valley of the Mississippi, and it has been found to be a constituent of coal. It seems to be beneficial to marine plants, and they have the power of abstracting it from sea-water. It is from these plants that almost all the iodine of commerce is derived.

Kelp, or the half vitrified ashes of seaweeds, prepared by the inhabitants of the Western Islands and the northern shores of Scotland and Ireland, is treated with water, and the solution filtered. The liquid is then concentrated by evaporation until it is reduced to a very small volume, the chloride of sodium, carbonate of soda, chloride of potassium, and other salts, being removed as they successively crystallize. The dark brown mother-liquor left, contains very nearly the whole of the iodide; this is mixed with sulphuric acid and peroxide of manganese, and gently heated in a leaden retort, when the iodine distils over and condenses in the receiver. The theory of the operation is exactly analogous to that of the preparation of chlorine; it requires in practice, however, careful management, otherwise the impurities present in the solution interfere with the general result.

The manganese is not really essential; the iodide of potassium or sodium, heated with an excess of sulphuric acid evolves iodine. It is probable that this effect is due to a secondary action between the hydriodic acid first produced and the residue of the sulphuric acid, in which both suffer decomposition, yielding iodine, water, and sulphurous acid.

Iodine crystallizes in plates or scales of a bluish black color and imperfect metallic lustre, resembling that of plumbago; the crystals are sometimes very large and brilliant. Its density is 4·948. At 225° it fuses, and at 347° boils, the vapor having an exceedingly beautiful violet color. It is slowly volatile, however, at common temperature, and exhales an odor much resembling that of chlorine. The density of the vapor is 8·716. Iodine requires for solution about 7000 parts of water, which nevertheless acquires a brown color; in alcohol it is much more freely soluble. Solutions of hydriodic acid and the iodides of the alkaline metals also dissolve a large quantity; these solutions are not decomposed by water, which is the case with the alcoholic tincture.

This substance stains the skin, but not permanently; it has a very energetic action upon the animal system, and is much used in medicine.

One of the most characteristic properties of iodine is the production of a splendid blue color by contact with the organic principle starch. The iodine for this purpose must be free or uncombined. It is easy, however, to make the test available for the purpose of recognising the presence of the element in question when a soluble iodide is suspected; it is only necessary to add a very small quantity of chlorine-water, when the iodine, being displaced from combination, becomes capable of acting upon the starch.

Iodine is now extensively used by the Daguerreotypist to coat the silver plate with so as to form a surface sensitive to light; generally the pure iodine is used in the coating, occasionally the chloride of iodine is preferred. Iodine is also used by the French to produce a blue color adapted for dyeing cotton with.

Iodine, Chloride of, is a preparation used in daguerreotyping. It is made by passing chlorine gas through iodine until the whole becomes liquid. Iodine readily absorbs chlorine forming when the chlorine is in excess a solid yellow compound, and when the iodine preponderates a brown liquid; the solid iodide is decomposed by water. The liquid is not, and is that which is used in the arts. It is a yellow, oily liquid, of a suffocating smell and astringent taste, soluble in water and alcohol. It consists of 1 equivalent of chlorine united with 1 equiv. of iodine.

IRIDIUM is a metal discovered by Descotils, in 1803, as also by Tenant, in 1804; and is so called because its different solutions exhibit all the colors of the rainbow. It occurs only in the ore of platinum, being found there in two states; 1. united to that metal, and 2. as alloy of osmium and iridium, in the form of small, insulated, hard grains. Iridium is the most refractory of all the metals; and appears as a gray metallic powder. It is not fused by the flame of the hydro-oxygen lamp.

IRON. Every person knows the manifold uses of this truly precious metal; it is capable of being cast in moulds of any form; of being drawn out into wires of any desired strength or fineness; of being extended into plates or sheets; of being bent in every direction; of being sharpened, hardened, and softened at pleasure. Iron accommodates itself to all our wants, our desires, and even our caprices; it is equally serviceable to the arts, the sciences, to agriculture, and war; the same ore furnishes the sword, the ploughshare, the scythe, the pruning hook, the needle, the graver, the spring of a watch or of a carriage, the chisel, the chain, the anchor, the compass, the cannon, and the bomb. It is a medicine of much virtue, and the only metal friendly to the human frame.

The ores of iron are scattered over the crust of the globe with a beneficent profusion, proportioned to the utility of the metal; they are found under every latitude, and every country which possesses a range of primary rocks is sure to have beds of iron ore. When pure it is a metal of a bluish-gray color, and a dull fibrous fracture, but it is capable of acquiring a brilliant surface by polishing. Its specific gravity is 7·78. It is the most tenacious of metals, and the hardest of all those which are malleable and ductile. It is singularly susceptible of the magnetic virtue, but in its pure state soon loses it. When rubbed it has a slight smell, and it imparts to the tongue a peculiar astringent taste, called chalybeate. In a moist atmosphere, iron speedily oxydizes, and becomes covered with a brown coating, called rust.

There are no less than 19 ores of iron : 1, native iron of three kinds, pure, metalliferous, and steely ; 2, arsenical iron ; 3, yellow sulphuret of iron ; 4, white sulphuret of iron ; 5, magnetic sulphuret ; 6, black oxide, either the loadstone, the magnetic, or titaniferous ; 7, *Fer oligiqiste*, **either specular or scaly ; 8, hæmatite, yielding red powder ; 9, yellow hæmatite, a hydrated oxide ; 10, pitchy iron ore ; 11, silico calcareous iron or zenite ; 12, sparry carbonate and clay iron stone ; 13, phosphate of iron ; 14, sulphate of iron, native copperas ; 15, chromate of iron ; 16, arseniate of iron ; 17, chloride of iron ; 18, oxalate of iron ; 19, titanate of iron.**

Of these ores 10 are worked by the miner of the native iron, the magnetic oxide, the carbonate, or clay iron stone. The hæmatite and the brown iron stone are the most important.

The *native* iron occurs in veins generally and is almost pure iron. The meteoric iron contains nickel, and the mass is magnetic.

The magnetic oxide or magnetic iron ore is a mixture of protoxide and peroxide, and contains, according to Berzelius, in 100 parts:

Iron	71·74
Oxygen	28·26

It is of an intense black color crystallized in regular octohedra, sometimes in granular or compact masses ; its sp. gr. 5·094. This variety is found in Warwick, Orange Co., New-York. The magnetic iron exists in the primary rocks of New England, and crosses New-York and New Jersey into Pa. It occurs at Winchester and Franconia, N. H., at Cumberland, R. I., at Hawles and Bernardstown, Mass. Near Ringwood, along the Highlands, beds of ore 10 feet thick exist ; in Morris county, New York, its average thickness is from 5 to 12 feet, and it yields 65 per cent. of pure iron. In the primary hills W. of Lake Champlain, there are numerous veins and beds of it 25 feet thick in some places and nearly pure. It is worked at Peru and Crown Point. This ore, besides being so rich in iron, yields it of the greatest purity ; hence that of Dannemora, in Sweden, has been so highly prized.

Chromate of iron, or chrome iron ore, is found massive and crystallized in octohedra, imperfect lustre, color brown black, sp. gr. 4·49. It consists of—

Oxide of chrome	55·50
Protoxide of Iron	33·
Alumina	6·
Silica	2·

does not fuse before the blowpipe ; it is magnetic after exposure to the reducing flame ; it forms a green bead with borax. In the United States it exists abundantly in Maryland, near Baltimore, also in small quantities near New Haven, Conn., in limestone with serpentine. It is used for extracting chrome salts. (*See* CHROME.) The quantity of chromate of lead annually made in Baltimore exceeds 80,000 lbs.

Specular iron ore and red iron ore occurs in many crystalline forms derived from the acute rhomboid, lustre metallic, color dark steel gray iron black ; streak cherry red sp. gr. 5·25, has full action on the magnet. The micaceous iron ore and the hæmatite, analyzed by Bucholz, have yielded in 100 parts,

Peroxide of iron	90·00	94·00
Oxide of manganese	a trace	a trace
Silica	2·00	2·00
Lime	a trace	1·00
Water	2·00	3·00

It yields ordinarily 60 per cent. of metal. The island of Elba is the most celebrated locality which has afforded iron for sixteen centuries. It has been worked at Hawley, Mass. It is however found but sparingly in the United States. It occurs at Ticonderoga, New-York, where it is ground to powder, and employed as a polishing substance. It affords excellent iron, and often as much as 60 per cent. It occurs also at Marietta, Ohio.

The brown iron ore, or hydrated oxide, does not occur crystalline, but in botryoidal masses, or in stalactitic lumps ; sometimes in pieces earthy and friable ; its spec. grav. is 3·922. Its composition is—proxide of iron, 84·00 ; water, 11·00 ; oxide of manganese, 2·00 ; silica, 2·00. Its most remarkable deposit in the United States is at Salisbury, Conn., where it has been wrought for nearly 100 years. This is the most extensive mine in the country, yielding 3000 tons per annum. Other localities of brown hæmatite exist in Litchfield, Conn., as well as in the vicinal county of Duchess, New-York, and Berkshire Mass. The iron which this variety affords is superior in malleability to that yielded by the red ore of iron, and is much esteemed also. This ore is abundant in Pa., yielding from 45 to 55 per cent. of metal. Hæmatite is abundant in Wisconsin. Iron was first found in this country in Virginia, in 1715. In many parts of Missouri the iron is so pure as not to require the preliminary roasting, and the iron mountain of that state has a circuit of two miles, and an elevation of 850 feet. It consists of specular iron, yielding 70 per cent. of metal, and contains only a few crystals of felspar.

The general principles which regulate the treatment of ores, will be found given under the article, *Metallurgy*. Some general notions of the particular treatment of iron ores are given here. After raising the ore it has to be picked, to separate valuable from worthless ore, or mere stone. They are next roasted in large heaps in the open air to drive off the sulphur and arsenic which they usually contain, and also render them more friable and easier to be powdered. In England the roasting is conducted with bituminous coal, but in this country altogether with charcoal. Trunks of trees and brushwood are laid down and overlaid with charcoal, and ignited. Upon the top of this the ore is heaped several feet high. After being roasted the ore is transferred to the crushing mill, where it undergoes another powdering, when it is transferred to the smelting furnace to be converted into iron. Here it passes through two distinct operations: 1. The reduction of the oxide to the state of pure metal; 2. The separation of the earthy matters as scoriæ.

These processes consist in exposing the ore, generally mixed with fluxes, to the action of carbon at a high temperature in furnaces, urged by bellows, hence called blast furnaces, or sometimes high furnaces.

The height of the blast furnace is very variable; some being only 36 feet high including the chimney, while others have an elevation of 60 feet. These extreme limits are very rare: so that the greater part of the furnaces are from 45 to 50 feet high. They are all terminated, by a cylindrical chimney of from 8 to 12 feet long; being about one fifth of the total height of the furnace. The inside diameter of this chimney is the same as that of the throat or mouth; and varies from 4 to 6 feet. The chimney is frequently formed of a single course of bricks, and acquires solidity from its hoops of iron, so thickly placed that one half of the surface is often covered with them. At its lower end, the mouth presents one or two rectangular openings, through which the charge is given. It is built on a basement circle of cast-iron, which forms the circumference of the throat; and a sloping plate of cast-iron is so placed as to make the materials slide over into the furnace, as shown in the figure.

The inside of the blast furnaces of Staffordshire is most frequently of a circular form, except the hearth and working area. The inner space is divided into four portions, different in their forms, and the functions which they fulfil in the smelting of the ore.

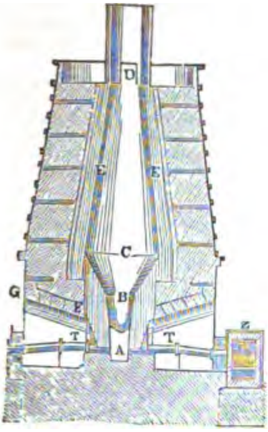
The undermost, called the hearth, or crucible, in which the cast-iron collects, is a right rectangular prism, elongated in a line perpendicular to the axes of the tuyères. The sides of the hearth consist in general of refractory sandstone (fire-stone), obtained mostly from the bed of the coal basin, called *millstone grit*; and the bottom of the hearth is formed of a large block of the same nature, laid on a cast-iron plate. In this country it is chiefly a mica slate, or gneiss rock, containing a large mixture of quartz.

The second portion is also made of the same refractory grit stone. It has the form of a quadrangular pyramidal, approaching considerably to a prism, from the smallness of the angle included between the sides and the axis.

The third portion, or lower body of the furnace, is conical, but here the interior space suddenly expands; the slope outwards at this part seems to have a great influence on the quality of the cast-iron obtained from the furnace. When No. 2 of the blackest kind is wanted for castings, the inclination of this cavity of the furnace is in general less considerable than when No. 2 cast-iron for conversion into bar-iron is required. The inclination of this conical chamber, called the boshes, varies from 55 to 60 degrees with the horizon. The diameter of this part is equal to that of the belly, and is from 11 to 18 feet. The boshes are built of masonry, as shown in the following figure.

The fourth part, which constitutes about two thirds of the height of the furnace from the base of the hearth up to the throat, presents the figure of a surface of revolution, generated by a curve whose concavity is turned towards the axis of the furnace, and whose last tangent towards the bottom is almost vertical. This surface is sloped off with that of the boshes, so that no sharp angle may exist at the belly. In some furnaces of considerable dimensions, as in that with three tuyères, this portion of the furnace is cylindrical for a certain height.

The conical orifice called the tuyère, in which the tapered pipes are placed, for imparting the blast, is seen near the bottom of the furnace, *fig.* 59, at A. Noso tubes of various sizes, from 2 to 4 inches in diameter, are applied to the extremity of the main blast-pipe. Under A is the bottom of the hearth, which, in large furnaces, may be two feet square. B is the top of the hearth, about two feet six inches square. A B is the height of the hearth, about six feet six inches. B shows the round bottom of the conical or funnel part, called in this country the *boshes*, standing upon the square area of the hearth. C is the top of the boshes, which may be about 12 feet in diameter, and 8 feet in perpendicular height. D is the furnace top or mouth, (*gueulard* in French,) at which the *materials are charged*. It may be 4½ feet in diameter. The line between C, D, is the height of the internal cavity of the furnace, from the top of the boshes upwards, supposed to be 30 feet. A, D, is the total height of the interior of the furnace, reckoned at 44½ feet. E E is the lining, which is built in the nicest manner with the best fire-bricks, from 12 to 14 inches long, 3 inches thick, and curved to suit the circle of the cone. A vacancy of 3 inches wide is left all round the outside of the first lining by the builder; which is sometimes filled with coke dust, but more generally with sand firmly rammed. This void space in the brick-work is for the purpose of allowing for any expansion which might occur, either by an increase in the bulk of the building, or by the pressure and weight of the materials when descending to the bottom of the furnace. Exterior to E E is a second lining of fire-bricks similar to the first. At F, on either side, is a cast-iron lintel, 8½ feet long, by 10 inches square, upon which the bottom of the arches is supported. F, G, is the rise of the tuyère arch, which may be 14 feet high upon the outside, and 18 feet wide. The extreme size of the bottom or sole of the hearth, upon each side of A, may be 10 feet square. This part and the boshing stones are preferably made from a coarse sandstone grit, containing large rounded grains of quartz, united by a siliceo-argillaceous cement.



The blowing machines employed in Staffordshire are generally cast-iron cylinders, in which a metallic piston is exactly fitted as for a steam engine, and made in the same way. Towards the top and bottom of the blowing cylinders, orifices are left covered with valves, which open inside when the vacuum is made with the cylinders, and afterwards shut by their own weight. Adjutages conduct into the iron globe or chest, the air expelled by the piston, both in its ascent and descent; because these blowing machines have always a double stroke.

As soon as the blast furnace gets into a regular heat, which happens about 15 days or three weeks after fires have been put in it, the working consists simply in charging it, at the opening in the throat, whenever there is a sufficient empty space; the only rule being to keep the furnace always full. The coke is measured in a basket, thirteen of which go to the ton. The ore and the flux (limestone) are brought forwards in wheel-barrows of sheet iron. In 24 hours, there are thrown into a furnace the following: 14⅓ tons of coke, 16 tons of roasted ore, and 6¾ tons of limestone; from which about 7 tons of pig iron are procured. This is run off every 12 hours; in some works the blast is suspended during the discharge. The metal intended to be converted into bar iron, or to be cast again into moulds, is run into small pigs 3 feet long, and 4 inches diameter; weighing each about two hundred weight and a half.

The disorders to which blast furnaces are liable have a tendency always to produce white cast-iron. The color of the slag or scoriæ is the surest test of these derangements, as it indicates the quality of the products. If the furnace is yielding an iron proper for casting into moulds, the slag has a uniform vitrification, and is slightly translucid. When the dose of ore is increased in order to obtain a gray pig iron, fit for fabrication into bars, the slag is opaque, dull, and of a greenish-yellow tint, with blue enamelled zones. Lastly, when the furnace is producing a white metal, the slags are black, glassy, full of bubbles, and emit an odor of sulphureted hydrogen. The scoriæ from a coke are much more loaded with lime than those from a charcoal blast furnace. This excess of lime appears adapted to absorb and carry off the sulphur, which would otherwise injure the quality of the iron. The slags, when breathed on, emit an argillaceous odor.

A blast furnace of 50 or 60 feet in height gives commonly from 60 to 70 tons of cast-iron per week; one from 50 to 55 feet high, gives 60 tons; two united of 45 feet produce together 100 tons; and one of 36 feet furnishes from 30 to 40. A blast furnace should go for four or five years without needing restoration. From 3½ to 4 tons of coal, inclusive of the coal of calcination, are required in Staffordshire to obtain one ton of cast-iron; and the expense in workmen's wages is about 15 shillings British on that quantity.

Heated air is applied in some iron-works. Where this method of working the ore has been introduced, the air is blown by cylinder-bellows in the usual manner, but before entering the smelting-furnace it passes through pipes of cast-iron, heated to redness, which are altogether about thirty feet in length and three feet in diameter. They are usually made in three or four pieces, joined together by apertures considerably less than three feet in diameter, and placed horizontally, or in whatever manner the local arrangements about the furnace may render most convenient. A brick arch is then thrown round the pipes, leaving a free space of about eight inches, and upwards, between it and them, and two or more furnaces constructed, so as to heat the pipes in the archway, the flues playing into it, and terminating in a common vent at the farther extremity. They may be considered, therefore, as placed on the floor of a long and narrow reverberatory furnace, about six feet high, and nearly of the same breadth, being at the same time protected by fire-bricks, when they might be injured by the direct flame of the furnaces. The iron ore is smelted, according to this plan, with little more than half the coal necessary when the furnaces are worked with air in the usual manner; the small coal, which is sold at an inferior price, is found quite sufficient for heating the pipes.

The number of charges in English furnaces, given in 12 hours, is different, in different furnaces, being 20, 25, and even up to 40; 30 is an average. Each charge is composed of from 5 to 6 cwts. of coke (or now of 3 to 4 cwts. of coal with the hot blast); 3, 4, and sometimes 6 cwts. of the roasted mine, according to its richness and the quality of cast iron wanted; the limestone flux is usually one third of the weight of the roasted iron stone. There are 2 casts in 24 hours; one at 6 in the morning, and another at 6 in the evening.

According to M. Berthier's analysis, the slag or cinder of Dowlais furnace consists of silica, 40·4; lime, 38·4; magnesia, 5·2; alumina, 11·2; protoxyde of iron, 3·8; and a trace of sulphur. He says that the silica contains as much oxygen as all the other bases united; or is equivalent to them in saturating power; and to the excess of lime he ascribes the freedom from sulphur, and the good quality of the iron produced. The specimen examined was from a furnace at Merthyr-Tydvil. Other slabs from the same furnace, and one from Dudley, furnished upwards of 2 per cent of manganese. Those which he analyzed from Saint Etienne, in France, afforded about 1 per cent. of sulphur.

As the ignition in the blast furnace proceeds, and the blast let on, the metal in the ore parts with its oxygen, and subsides to the bottom of the furnace, covered with a melted slag. This last is occasionally allowed to flow off, by opening some of the side holes which were stopped with clay, and when the bottom of the furnace becomes charged with metal, which it does after five or six hours, the iron itself is discharged, by one of these openings, into a pit of sand mixed with clay. As soon as the iron is poured out, the hole is closed, and the furnace is still kept at work, and goes on reducing iron for six months. The flux employed to assist the fusion of the ore, by vitrifying the earths aforesaid with iron, is limestone of the best quality; very lately, it has been proposed to use caustic lime, or that which has been burned, instead of the crude limestone. It is said to produce an economy of fuel.

The iron which has run out from the furnace, is *cast iron*, or iron with carbon intermingled with it, sometimes to the extent of 5 per cent. It has a coarse grain, and is very brittle. The mould in which the metal flows, is of a longish shape, having projecting offsets on each side, which, from some fancied resemblance to a sow and her litter, has been called *pig iron*.

To convert this pig or crude iron into bar iron, it has to be *refined*. This consists in placing it in a furnace, like a smith's forge, or hearth, with a sloping cavity sunk a foot below the blast pipe.

In the finery process, the hearth or crucible of the furnace is filled with coke; then six pigs of cast iron are laid horizontally on the hearth, namely, four of them parallel to the four sides, and two in the middle above; and the whole is covered up in a dome-form, with a heap of coke. The fire is now lighted, and in a quarter of an hour the blast is applied. The cast iron flows down gradually, and collects in the crucible; more coke being added as the first quantity burns away. The operation proceeds by itself; the melted metal is not stirred about, as in some modes of refinery, and the temperature is always kept high enough to preserve the metal liquid. During this stage the coals are observed continually heaving up, a movement due, in part, to the action of the blast, and in part to an expansion caused in the metal by the discharge of gaseous oxyde of carbon. When all the pig iron is collected at the bottom of the hearth, which happens commonly at the end of two hours, or two and a half, the tap-hole is opened, and the *fine* metal flows out with the slag, into the loam-coated pit, on a plate 10 feet long, and 3 broad, and from 2 inches to 2¼ thick. A portion of the slag forms a small crust on the surface of the metal; but most part of it collects in a basin scooped out at the bottom of the pit, into which the fine metal is run.

A large quantity of water is thrown on the metal, with the view of rendering it brittle, and perhaps of partially oxydizing it. This metal, suddenly cooled, is very white, and possesses in general a fibrous radiated texture; or sometimes a cellular, including a considerable number of small spherical cavities, like a decomposed amygdaloid rock. If the cast iron be of bad quality, a little limestone is occasionally used in the above operation.

Three samples of cinder, analyzed by Berthier, gave:

1. Silica, 0·276; protox. of iron, 0·612; alumina, 0·040; phosp. acid, 0·072, Dudley.

2. Silica, 0·368; protox. of iron, 0·610; alumina, 0·015; puddling of Dowlais.

8. Silica, 0·424; protox. of iron, 0·520; alumina, 0·033; puddling of Dowlais.

The remarkable fact of the presence of phosphoric acid, shows how important this operation is to the purification of the iron. The charge varies from a ton and a quarter to a ton and a half of pigs; and the loss by the process varies from 12 to 17 per cent.

The fine metal thus obtained is broken in pieces, and sent to the puddling furnace. This is a reverberatory furnace, which is charged by shovelling in the fine metal, and laying it all round the sides of the earth, raising the heap to the roof; the middle of the hearth is left clear. The fuel is then placed in the grate, and the doors closed; in 20 minutes the metal becomes white, melts, and falls in drops to the sole of the furnace; the fire is then gradually checked, and the pieces separated so that the whole may not become too fluid, but remain as a pasty mass; as the heat is continued and stirred, the mass gets drier, and carbonic oxide, which at first was freely given, now gradually lessens, and ultimately ceases.

The workman, with his paddle, now works the mass into lumps or balls of 70 lbs. weight. The balls are lifted out, and are fit for being hammered. The whole object of the puddling has been to remove the carbon out of the iron, to which its fluidity was due; as the carbon escapes, the fusibility of the mass diminishes.

The puddled balls have now to undergo the next process, which is that of hammering or condensing the fibres, of welding them, and giving the mass the form of a *bar*.

In England there are employed for the forging and drawing out of the iron, cast-iron hammers of great weight, and cylinders of different dimensions, for beating out the balls, or extending the iron bars, as also powerful shears. These several mechanisms are moved either by a steam engine, as in Staffordshire, and in almost all the other counties of England, or by water-wheels when the localities are favorable, as in many establishments in South Wales. We shall here offer some details concerning these machines.

The main driving shaft usually carries at either end a large toothed wheel, which communicates motion to the different machines through smaller toothed wheels. Of these, there are commonly six, four of which drive four different systems of cylinders, and the two others work the hammer and the shears. The different cylinders of an iron work should never be placed on the same arbor, because they are not to move together, and they must have different velocities, according to their diameter. In order to economize time and facilitate labor, care is taken to associate on one side of the motive machine the hammer, the shears, and the reducing cylinders; and, on the other side to place the several systems of cylinders for drawing out the iron into bars. For the same reason the puddling furnaces ought to be grouped on the side of the hammer; and the reheating furnaces on the other side of the works.

The hammers are made entirely of cast-iron; they are nearly 10 feet long, and consist usually of two parts, the helve and the head or pane. The latter enters with friction into the former, and is retained in its place by wedges of iron or wood. The head consists of several faces or planes receding from each other; for the purpose of giving different forms to the ball lumps. A ring of cast-iron called the *cam-ring bag*, bearing movable cams, drives the hammer, by lifting it up round its fulcrum, and then letting it fall alternately. In one iron work, this ring was found to be 3 feet in diameter, 18 inches thick, and to weigh 4 tons. The weight of the helve (handle) of the corresponding hammer was 3 tons and a half, and that of the head of the hammer, 8 hundred weight.

The anvil consists also of two parts; the one called the pane of the anvil, is the counterpart of the pane of the hammer; it likewise weighs eight hundred weight. The second, named the stock of the anvil, weighs 4 tons. Its form is a parallelopiped, with the edges rounded. The *bloom* or rough ball, from the puddle furnace, is laid and turned about upon it, by means of a rod of iron welded to each of them, called a *porter*. Since the weight of these pieces is very great, and the shocks very considerable, the utmost precautions should be taken in setting the hammer and its anvil upon a substantial mass of masonry, as shown in the figure, over which is laid a double, or even quadruple flooring of wood, formed of beams placed in transverse layers close to each other. Such beams possess an elastic force, and thereby partially destroy the injurious reaction of the shock. In some works, a six-feet cube of cast iron is placed as a pedestal to the anvil.

Forge hammers are very frequently mounted as levers of the first kind, with the centre of motion about one third or one fourth the length of the helve from the cam wheel.

When well hammered by these trip hammers, the mass is made to pass between grooved cylinders, which press it into the bar shape; as it emerges from the cylinders it is cut with a shears into shorter lengths.

Such is a rough outline of the mode of obtaining bar or wrought iron, as practised in England. In France, and the south of Europe, as well as in many places in this country, it is differently conducted.

Malleable iron is frequently obtained direct from the ores by one fusion, when the metallic oxide is not too much contaminated with foreign substances; this mode, which is allowed to be much more economical than the one described, as it saves time and combustibles, has for a long period been employed in Catalonia, in the Pyrenees, from which circumstances it is called the method of the Catalan forge. Those ores, best adapted to its treatment, are the pure black oxide, red and brown oxide, and carbonate of iron; to extract the metal from which, it is sufficient to expose them to a high temperature in contact with charcoal or carbonaceous gases. The furnace employed is similar to the refining forge previously described. The crucible is a semicircular or oblong basin, 18 inches diameter, and 8 or 10 deep, excavated in an area or small elevation of masonry 8 or 10 feet long, by 6 broad, and covered in with a chimney. The tuyères stand 5 or 6 inches above the basin, and have a slight inclination downwards, and the blast is given by a water blowing machine. The first step consists in expelling the water combined with oxide, as well as the sulphur and arsenic. When those combinations are present, this is done as usually by roasting in the air. The roasted ore is crushed to a fine powder, and thrown by the shovel at intervals on the charcoal fire of the hearth; the side sand bottom of the basin being previously lined with two or three brasgues (coats of pounded charcoal). It gradually softens and unites into lumps, more or less coherent, which finally melt and accumulate in the bottom of the crucible or basin, and a thin slag is occasionally let off from the upper surface of the melted iron by the holes, which can be opened at discretion. The melted iron preserves a pasty condition, owing to the heat communicated from above, and when a mass sufficiently large is accumulated, it is removed, put under the hammer, and forged at once. A lump or *bloom* of malleable iron is thus produced in three or four hours. The iron is generally soft, very malleable, and a little steely. Four workmen are employed at one forge, and by a relief every six hours, they can make 86 cwt. of iron per week. 100 pounds of iron are obtained, in this forge, from 300 lbs. of ore. This process, generally called *blooming*, is one now increasing in this country.

Mr. W. Lyman first put into successful operation at Pottsville, Pa., in 1830, a furnace for smelting iron by anthracite with the hot blast. In 1840, Messrs. Biddle, Chambers & Co. did the same at Dansville, Pa., and others followed.

Anthracite coal is now always used with hot air in smelting, and the puddling is performed by Detmold's patent, with ignited gas. In Maryland bituminous coal is used, in New York charcoal. Blooming or making the bar iron by one operation, without the use of the blast furnace is common in Connecticut, New York, and Vermont.

In 1845, Clinton and Essex Co., N. Y., produced 13,000 tons of iron. The whole produce in the States same year was estimated at 919,100 tons = $41,734,610. In New-York, the mines of Dutchess and Columbia Co. yield 20,000 tons annually; Essex Co. 1,500 tons, Clinton 8,000, Franklin 600: St. Lawrence 2,000, amounting in all to a value of more than $500,000. In Ohio 1200 square miles are underlaid with iron, and calculated to contain 1,080,000,000 tons. In Tennessee 100,000 tons are manufactured yearly.

The following is the process recently adopted by Mr. Alexander Dickson, of Newark.

"The fire is placed at the end, under a horizontal bed of fire-brick some twelve or fifteen feet in length—the fire passing through to the other extremity. In the centre, and over the bed, is erected a double cylinder, which is filled with crushed ore and pulverized anthracite coal. The intense flame surrounds the cylinder, and also passes through the inner cylinder, which removes the oxygen and all other impurities with the presence of atmospheric air. Being thus prepared, the ore gradually melts and descends to the hearth, where it first comes in contact with the fire, which destroys the remainder of the pulverized coal by frequent stirring, and the iron is thus partially formed. From this hearth it is thrown to another about eight inches lower than the first, where it is worked into balls of about one hundred pounds amid the same sheet of fire, and in a few minutes the ball is withdrawn and put under the hammer to put it in shape, which concludes the process.

Mr. Wall, of England, has patented a process for removing the phosphorus out of iron. The process consists of two parts; first, in adding certain substances to the metal, while in a state of fusion; 2nd, in applying electricity to the metal while in a state of fusion, and during its cooling. In carrying out the first part, two compounds are made use of, termed A and B.

The compound A is formed by mixing two parts of iron filings or turnings with five parts of black resin, by melting the resin and stirring in the iron filings. When the mass has sufficiently cooled it is made into balls of about five pounds weight each; and in using them these balls are thrown in the melting-furnace on the surface of the fused metal, in the proportion of one of the balls to every 5 cwt. of metal. The compound B is formed by thoroughly mixing two parts of common salt and five parts of resin, turpentine, or other carbonaceous matter, and making this also into balls of about five pounds each, and throwing these on to the surface of the melted metal, in the proportion of one pound to each cwt. of the metal, after the compound A has been employed. In carrying out the second part, a battery is employed, consisting of platinum and zinc plates, containing eight pairs, 6 inches by 4 of active surface, in separate cells of dilute sulphuric and strong nitric acid, arranged in the manner commonly known as Grove's battery, or 32 pairs of same sized plates, arranged in the manner commonly known as Smee's battery, which give sufficent electricity for all general purposes. In applying the electric current a rod of iron is inserted into each extremity of the mould, into which the metal is to be cast, if the casting be horizontal; or into the bottom and top of the mould, if the casting is vertical. These two rods of iron are connected with the two poles of the battery respectively; and when the melted metal is poured into the mould, it serves to complete the circuit, and electricity will continue to traverse it as long as the connection with the poles of the battery remains unbroken. The current should be kept up for a considerable time even after the metal has solidified; but if continued for too long a time, the metal would be decarbonated and converted into wrought iron. The patentee also passes an electric current through the fused metal while in the furnace, by inserting a rod of iron in the lower part of the furnace so as to be in contact with the metal, which rod is attached to one pole of the battery, while another rod in connection with the opposite pole is moved by the operator in constant contact with the melted mass, over every part of the surface, thus directing the current through every portion of it.

Overman, in his work, says, "Hydrated Oxide of Iron, Brown Oxide, Hematite Bog Ore, should all be roasted, not for the purpose of oxidation, but to drive off the acids, and destroy the sulphurets and phosphurets—all ores of this class contain more or less injurious matter. Sulphates of iron should be carefully roasted, so should phosphates, with a liberal access of air."

The more carbon that is present, the greater difficulty there is to drive off the phosphorus, for carbon is necessary in every case to produce a combination of phosphorus with the metal—the process of Wall, therefore, in expelling the carbon, would lead to infer that it would be most suitable for the removal of phosphorus, and sulphur also.

Mr. Thompson, of Newcastle-on-Tyne, England, has patented an improved furnace. The nature of the invention consists of two parts. First, the construction and working of the furnace. Second, the application of the gases generated in the furnace to subsequent useful purposes.

The body of the furnace, is constructed somewhat in the ordinary manner; the top of it is of a dome shape, and surmounted by a throat, the upper end of which can be closed by iron plate, which is intended to fit as air-tight as practicable, and when removed, it is through this aperture that the furnace is charged. Above the dome, and around the throat, is the circular tunnel or chamber; it communicates by the apertures or short flues, with the body of the furnace in the upper part of the dome; from this tunnel, upon opposite sides of the furnace, proceed vertical pipes; these are intended to carry off the gases; two steam pipes at their lower ends communicate with a steam boiler behind the furnace, from which the steam is supplied: the steam pipes pass upwards into the centre of the vertical pipes, and their ends terminate in a number of steam jets, arranged so as to produce the best effects of exhaustion; the tuyers are arranged in the usual manner and intended to supply air to the furnace by draught, either in a cold or hot state. The exhaust pipes are about eighteen inches in diameter, and the diameter of the steam pipes is about four inches. The steam jets being in action, they cause an exhausting action in the pipes, thereby drawing the gases generated in the furnace through the short flues and tunnel, and effecting the necessary working of the furnace. The lid is lifted from its seat occasionally, for the purpose of charging the furnace, but this is to be done as seldom as possible, as at these times the exhausting action of the steam jets is to be stopped, and the consequent working of the furnace suspended. This method, therefore, is to do away with the blower, and use exhaust by steam as a substitute.

The second improvement is, the employing the gases generated in the furnace, in the above described operation, to subsequent useful purposes, as heating the refinery and other furnaces, or generating steam in steam boilers; to effect this, the vertical pipes are dispensed with, and the gases generated are carried by a pipe from the tunnel to the furnace where they are to be employed. The steam jets or other exhausting means are then employed in the exit or chimney from this furnace, instead of the smelting furnace, as above.

The following is the comparative power of a few different metals, to sustain weights by suspension, according to Mr. Rennie's experiments, in bars one quarter of an inch square:

	lbs.
A cast-iron bar. hor. sustained	1166
A ditto, vertical	1218
A cast steel bar previously tilted	8391
A blister-steel bar, reduced by hammering	8322
A shear-steel bar, ditto	7977
A Swedish iron ditto, ditto	4504
An English iron ditto, ditto	3492
A hard gun-metal bar	2273
A wrought-copper bar	2112
A cast-copper ditto	1192
A fine yellow brass bar	1128
A cast-tin bar	296
A cast-lead bar	114

Pennsylvania is the largest iron manufacturing State; it does not manufacture of late years as much as previously, owing to the low price of imported iron. The following statistics are taken from the Scientific American:—

It appears that out of 62 counties which the State embraced at the date of the last report, 45 contain iron works, and 9 of the remaining 17 contain abundance of iron and coal—though, owing to the absence of any cheap road to market, they yet remain untouched—leaving only 8 counties in the State not adapted to the manufacture of iron.

There are 304 blast furnaces and bloomeries in the State, with an invested capital of $12,921,576; their present capacity is for the making of 550,959 tons per annum; in 1847, they made 389,350 tons; in 1849, 253,370 tons; in 1850, their probable make is estimated at 198,813 tons. Of the above furnaces 57 use anthracite coal; have a capital of $3,221,000, and a present capacity for making 221,400 tons; in 1847, they made 151,331 tons; in 1849, 109,168 tons, and the estimated product of 1850 is 81,351 tons. The furnaces using bituminous coal are 7 in number, with a capital of $223,000, and a present capacity for making 12,600 tons. In 1847, they made 7,800 tons; in 1849, 4,900 tons; in 1850, the make will probably be 3,900 tons. Four furnaces use coke, have a capital of $800,000, and a present capacity for making 12,600 tons, per annum; in 1847, they made 10,000 tons. Eighty-five are charcoal hot blast furnaces, with an investment of capital of $6,478,500, and a capacity for making 130,705 tons per annum. The make of 1847 was 94,519; 1849, 58,302; in 1850, it will be 42,555. The charcoal cold blast furnaces number 145, with a capital of $5,170,376, and a capacity for making 173,654 tons per annnm. The make of 1847, was 125,155; 1849, 80,655; in 1850, it will be 70,727. There are 6 bloomeries, with a capital of $28,700, and a capacity for producing 600 tons per annum. The product for 1847 was 545; 1848, 335; probable product of 1850, 280. The estimate for 1850, is obtained by deducting from the product of 1849 the amount made by such furnaces as are now idle. Of the 298 furnaces in the State, 149 or exactly one-half are in blast this year, and of these about one-third are making no preparations to blow during the next year. The estimate for 1850 shows a decrease of 190,537 since 1847, or 49 per cent. in three years. Should there be no change in the aspect of affairs, the make of 1851 will not exceed 100,000 tons.

The number of forges and rolling mills in the State is 200, with a capital of $7,580,500, with 402 forge fires, and 436 puddling furnaces, and a capacity to make 224,650 tons per annum. Their actual make for 1847 was 202,727 tons, and 1849, 186,853 tons. Of the above there are 121 charcoal forges, with an investment of capital amounting to $2,026,300. These forges have 402 fires, with a capacity of 125 tons per fire, per annum, or a total of 50,250 tons. In 1847, they made 39,997 tons, and in 1849, 28,495 tons. The rolling mills number 79, with a capital of $5,554,200. They contain 436 puddling furnaces, which, at 400 tons per furnace, gives a total capacity of 174,400 tons per annum. Their make in 1847, was 163,760 tons; and in 1849, 108,358 tons.

There are 606 nail machines in the State, the annual product of which is 606,000 kegs, or 30,300 tons; being an average of 1,000 kegs, of 100 lbs. each, to a single machine. There are 13 works engaged in the conversion of iron into steel, making annually 6,078 tons. Five of these works are in Philadelphia, six in Pittsburg, one in Lancaster, and one in York. The whole number of iron works in the State is 504, with a capital of $20,502,076 invested in lands and machinery, employing immediately 30,103 men, and 13,562 horses, besides 11,513 laborers not in the pay of the iron masters, but directly dependent on the iron works for support; making a total of 41,616 men. Allowing five persons to each laborer, and we have as the population dependent on the iron work, 208,080, or about one-tenth of the population of the State.

In 1847, the consumption of fuel in all the iron works of the State was 483,000 tons of anthracite coal, at an average value of $3 per ton, making $1,448,000; 9,007,000 bushels of bituminous coal, at 5 cents per bushel, making $450,380; and 1,490,252 cords of wood, at $2 per cord, $2,980,504. Thus giving the total cost of fuel $4,879,884.

To show how cheaply iron is obtained, and how the mechanical skill and labor expended upon it totally overshadow the original price, a number of the British Quarterly Review, of 1847, gave the following curious and instructive calculation:—

Bar iron worth £1 sterling is worth when worked into

	£	s.
Horse-shoes	2	10
Table knives	36	0
Needles	71	0
Penknife blades	657	0
Polished buttons and buckles	897	0
Balance springs of watches	50,000	0

Cast iron worth £1 sterling is worth when converted into

	£
Ordinary machinery	4
Larger ornamental work	45

Buckles and Berlin work	**£600**
Neck chains	**1,386**
Shirt buttons	**5,896**

Thirty-one pounds of iron have been made into wire upwards of 111 miles in length, and so fine was the fabric, that a part was converted, in lieu of horse hair, into a barrister's wig. The process followed to effect this extraordinary tenuity consists of heating the iron and passing it through rollers of 8 inches diameter going at the rate of 400 revolutions per minute down to No. 4 on the wire gauge. It is afterwards drawn cold, at Birmingham, down to 88 on the same gauge, and so on till it attains the above length in miles.

Of the quantity of iron manufactured in Great Britain, in 1848, South Wales produced 279½ thousand tons; Staffordshire, 219½; Shropshire, 81½; Scotland, 87½; Yorkshire, 33; Derbyshire, 22½; and North Wales, 25.

It is well known that it is most difficult to keep iron from oxidating or rusting on the surface; various plans have been adopted to accomplish the object of protecting the surface even in a slight degree. Some of these modes consisted in coating the surface; in others, it extended to an alloying of the melted mass. One method consists in the addition of pig iron, when in a state of fusion, of from 2 to 10 per cent. of copper, tin, nickel, or antimony, by which addition, the iron is rendered more malleable and less subject to oxidation. A second method consists in the giving to the iron a coating of steel, or rather a species of iron containing less carbon and of course approaching to steel. This is effected by the addition of one part of blister steel to four parts of molten cast iron, and then adding scrap iron to the mass, until an iron rod is no longer rendered brittle by being dipped in the mixture. With this compound, common iron is coated in the same manner as pursued in the case of covering iron with brass; but various methods are pursued, according to the size and nature of the article to be coated; where it is at the end of a bar of iron, such as an axle, and is to be of a particular form, this form may be given to the crucible, thereby making it a mould, and when in a state of perfect fusion, the iron, either previously heated or cold, is to be immersed in the melted mass, and when it is perceived that the mass is perfectly fluid, then the fire may be withdrawn, or the crucible be allowed to cool by any available means; but when the iron to be coated is immersed cold, the melted mass is immediately congealed, but it must be permitted to remain in the crucible till it again becomes fluid, and then it should be allowed to cool. If the whole is allowed to cool slowly, it is then soft, and may be turned in the lathe, and afterwards hardened by heating it and cooling it suddenly in the usual manner; but in this case care must be taken, as the coating and the iron have different powers of contracting. If the coated parts were suddenly immersed in water, it would certainly crack, the uncoated part must therefore be immersed up to the coated part, when the conducting power of the iron will cool the coating sufficiently quick to insure a proper hardness.

A third method of preventing oxidation, is case-hardening the metal, by the use of ferrocyanide of sodium, calcium or barium.

In order to apply the ferrocyanide, an alkaline bath, formed with carbonate of soda, or other alkali is used. This bath may be a crucible or large basin built in the brickwork of the furnace, which should be a reverberatory furnace, and previous to being used, should be raised to a white heat; the iron to be case-hardened requires to be previously heated to nearly a red-heat, and then immersed in the bath, and there raised to a heat sufficiently high, after which it must be immediately immersed in the ferrocyanide previously fused in another vessel; but if the quantity of iron to be case-hardened is small, it would not be advisable to fuse the ferrocyanide (as it is very soon decomposed), but immediately on taking it out of the bath it must be sprinkled with the ferrocyanide; should ferrocyanide of potassium be used, it is found that the alkaline bath prevents effectively the corroding of the iron.

A fourth scheme consists of a method of coating copper, or the alloys of copper or iron, with platinum. Platinum is dissolved in aqua regia, and the iridium which remains undissolved as a black powder, separated by filtration, then evaporated to dryness, and when cold a quantity of caustic potass, equal in weight to the metallic platinum employed is to be dissolved in water, and poured on the chloride of platinum. This will precipitate the platinum of an impure yellow color; a quantity of solution of oxalic acid equal to the weight of the metallic platinum, is now to be added without pouring off the solution which remains on the precipitate; the solution is then to be boiled till the precipitate is entirely dissolved; a small quantity of iridium will still remain, which, together with any other impurities, must be separated by filtration; caustic potass equal to twice the weight of the metallic platinum is to be dissolved in water and added to the above. The solution is now ready for platinizing the copper or iron article which is to be coated with platinum. The article to be coated is to be put in a vessel.

Iron in its pure state is malleable, and it is a combination of carbon with iron which produces cast-iron. In addition to carbon, the cast-iron in this country contains silica, lime, magnesia, alumina, occasionally some of the phosphates and other admixtures; but iron made from magnetic ores is much purer. The strength of cast-iron depends upon its freedom from impurities, and upon the proportion of carbon it contains. The strongest cast-iron contains about three per cent. of carbon, or, according to Mr. Charles May, when the carbon is in the smallest proportion that produces fluidity; a larger proportion tends to make the iron soft and weak, and a smaller hard and brittle. Mr. Glynn, in his evidence before the Strength of Iron Committee, in London, states, that the strongest iron generally shows a clear gray, or slightly mottled fracture, and he considers that the color indicates the combination of carbon with iron which produces the greatest strength. Mr. Stirling states, that while color is admissible as a test of strength, it is not so of chemical constitution, for though dark colored iron is usually brittle, yet black iron when chilled becomes white, although it must be supposed to contain the same quantity of carbon; hence, as a general rule, he concludes that color indicates the treatment to which iron has been subjected, and in some cases only the quantity of carbon. Mr. May coincides in considering the question of strength to be very much reducible to the quantity of carbon contained in the iron, as some of the tenderest iron skillfully treated will produce some of the strongest castings. Messrs. Stephenson and Stirling mention that the fluidity of Berlin iron is due to the presence of arsenic, and the latter has observed that manganese mixed artificially with cast-iron, closes the grain, and is an improvement both to cast-iron and steel. On wrought iron the effect of manganese is stated to be to give it the hot-short property, while cold-short is produced by the presence of a small quantity of phosphorus; and the admixture of arsenic renders wrought iron hard and brittle.

Iron Guns. Pig-iron of gray color should be melted in an air-furnace with an intense and rapid fire, for iron guns; but an alloy of copper and tin is used for brass guns. The first are used on shipboard and the latter for field artillery, with a bush of copper, as less fusible by firing, for the touch-hole.

The solid casting is then bored by the revolution of the gun, with an apparatus and steam power. A 24-pounder of iron is 10 ft. long, and weighs 52 cwt. with a bore of 5·824 inches, a ball of 5·547 inches and 8 lbs. of powder. A 24-brass pounder weighs 50 cwt. An iron 6-pounder weighs 24 cwt. and is 9 ft. long.

IVORY, is the tusk or tooth of defence of the male elephant. It is an intermediate substance, between bone and horn, not capable of being softened by fire, nor so hard and brittle as bone. Sometimes it is an enormous size, weighing nearly 200 lbs. It is of a yellowish, brownish, and sometimes a dark brown color on the outside, internally white, hollow towards the root, and so far as was inserted into the jaw, of a blackish brown color.

It is used for making ornamental utensils, mathematical instruments, cases, boxes, balls, combs, knife-handles, dice, and toys.

Guillot obtained from 100 parts of ivory, 24 gelatine, 64 phosphate of lime, and 0·1 carbonate of lime.

Ivory is restored in color, by covering it with quick-lime and pouring vinegar on this. After 24 hours rub it with alum-powder. The best ivory comes from Ceylon.

Ivory is very apt to take a yellow-brown tint by exposure to air. It may be whitened or bleached, by rubbing it first with pounded pumice stone and water, then placing it moist under a glass shade luted to the sole at the bottom, and exposing it to sunshine. The sunbeams without the shade would be apt to occasion fissures in the ivory. The moist rubbing and exposure may be repeated several times.

For etching ivory, a ground made by the following recipe is to be applied to the polished surface:—Take of pure white wax, and transparent tears of mastic, each one ounce; asphalt, half an ounce. The mastic and asphalt having been separately reduced to fine powder, and the wax being melted in an earthenware vessel over the fire, the mastic is to be first slowly strewed in and dissolved by stirring; and then the asphalt in like manner. This compound is to be poured out into lukewarm water, well kneaded, as it cools, by the hand, into rolls or balls about one inch in diameter. These should be kept wrapped round with taffety. If white resin be substituted for the mastic, a cheaper composition will be obtained, which answers nearly as well; 2 oz. asphalt, 1 oz. resin, ¼ oz. white wax, being good proportions. Callot's etching ground for copper plates, is made by dissolving with heat 4 oz. of mastic in 4 oz. of very fine linseed oil; filtering the varnish through a rag, and bottling it for use.

Either of the two first grounds being applied to the ivory, the figured design is to be traced through it in the usual way, a ledge of wax is to be applied, and the surface is to be then covered with strong sulphuric acid. The effect comes better out with the aid of a little heat; and by replacing the acid, as it becomes dilute by absorption of moisture, with concentrated oil of vitriol. Simple wax may be employed instead of the copper-plate engraver's ground; and strong muriatic acid instead of sulphuric. If an acid solution of silver or gold be used for etching, the design will become purple or black, on exposure to sunshine. The wax may be washed away with oil of turpentine. Acid nitrate of silver affords the easiest means of tracing permanent black lines upon ivory.

Ivory may be dyed by using the following prescriptions:—

1. *Black dye.*—If the ivory be laid for several hours in a dilute solution of neutral nitrate of pure silver, with access of light, it will assume a black color, having a slightly green cast. A still finer and deeper black may be obtained by boiling the ivory for some time in a strained decoction of logwood, and then steeping it in a solution of red sulphate or red acetate of iron.

2. *Blue dye.*—When ivory is kept immersed for a longer or shorter time in a dilute solution of sulphate of indigo (partly saturated with potash), it assumes a blue tint of greater or less intensity.

8. *Green dye.*—This is given by dipping blued ivory for a little while in solution of nitro-muriate of tin, and then in a hot decoction of fustic.

4. *Yellow dye* is given by impregnating the ivory first with the above tin mordant, and then digesting it with heat in a strained decoction of fustic. The color passes into orange, if some Brazil wood has been mixed with the fustic. A very fine unchangeable yellow may be communicated to ivory by steeping it 18 or 24 hours in a strong solution of the neutral chromate of potash, and then plunging it for some time in a boiling hot solution of acetate of lead.

5. *Red dye* may be given by imbuing the ivory first with the tin mordant, then plunging it in a bath of Brazil wood, cochineal, or a mixture of the two. Lac dye may be used with still more advantage, to produce a scarlet tint. If the scarlet ivory be plunged for a little in a solution of potash, it will become cherry red.

6. *Violet dye* is given in the logwood bath to ivory previously mordanted for a short time with solution of tin. When the bath becomes exhausted, it imparts a lilach hue. Violet ivory is changed to purple-red by steeping it a little while in water containing a few drops of nitro-muriatic acid.

With regard to dyeing ivory, it may in general be observed, that the colors penetrate better before the surface is polished than afterwards. Should any dark spots appear, they may be cleared up by rubbing them with chalk; after which the ivory should be dyed once more to produce perfect uniformity of shade. On taking it out of the boiling hot dye bath, it ought to be immediately plunged into cold water, to prevent the chance of fissures being caused by the heat.

Madame Bouvier (of Paris) adopts the following process (patented) for working in plastic ivory. Take the waste turnings of ivory, bone, horn, &c., and steep them in a waste acid solution. Nearly all the acids will serve for this purpose, but the following are preferable: muriatic, nitric, tartaric, acetic, citric, and oxalic, also phosphate of lime. The solution is placed in a water bath at a temperatue of 35° to 40° C., (95° to 105° Fahr..) in order to obtain complete liquefaction. It is then passed through fine muslin, and about one fourth the quantity of ivory gelatine is next added to absorb the solvent. When the paste is well prepared, the excess of liquid, and any foreign gases, are removed by means of the air pump: it thus become homogeneous, membranous, and very close. In this state it would be difficult to run it for use: for which purpose it must be dissolved in copal or lac varnish, and in this state it may be run into moulds. When the paste is in the moulds, it may be made to undergo pressure, to expel the air, and prevent the formation of air bubbles in the interior. Coloring matters may be added to the paste.

M. Charriere of Paris renders the ivory which he works into shapes, flexible by steeping it in hydrochloric acid. Either strong or diluted with water, the ivory becomes flexible, elastic, and yellow. As it dries it becomes hard again. The flexibility is however restored by wetting the ivory with a piece of linen.

Ivory Black is made by exposing ivory and bone-shavings in an iron cylinder, at a red heat, allowing the effluvia to rise through a pipe. It does not differ from bone black, being carbon in a very fine state.

JACK, is the name of a very powerful machine for raising great weights. Its ordinary power is 5 tons, or 200 times the force of man applied to the handle. The better sort are supplied with a ratchet, to prevent their running back.

JACK is also the name of a kitchen-machine for cooking, and the moving power is either a weight or the smoke and rarefied air of a chimney. It has a worm, or endless screw, with a main-wheel of 60 teeth, a worm-wheel of 30, and a pinion-wheel of 15.

This *smoke jack* is used for the same purpose as the common jack, and is so called because it appears to be moved by the smoke of the fire. It is in fact moved by the ascending current of rarefied air, which acts on a fan properly placed in the chimney. The motion may be obtained as above, or sometimes spiral flyers coiled about a vertical axis are employed, but more frequently a vertical wheel with oblique leaves like the sails of a windmill.

JACQUARD. (*See* SILK MANUFACTURE.)

JADE, the true *lapis nephriticus*, belongs to the siliceous order of minerals, as it gives fire with steel, and is semi-pellucid, like flint; it does not harden in fire, but melts, in the focus of a burning lens, into a transparent green glass, with some bubbles.

It contains ·47 silex, ·38 carbonate of magnesia, ·04 alumine, ·02 carbonate of lime, and ·09 iron.

Its spec. gravity is from 2·950 to 3·389.

The semitransparency, hardness, and specific gravity, are the characters by which the *lapis nephriticus* may be distinguished from other stones.

JAMBS. In architecture, the side or vertical pieces of any opening in a wall which bear the piece that discharges the superincumbent weight of such wall.

JAMESONITE. A mineral named after Professor Jameson. It occurs crystallized and massive: it consists of sulphur, lead, and antimony.

JAPANNING. The art of covering paper, wood, or metal with a thick coat of a hard brilliant varnish: it originated in Japan, whence articles so prepared were first brought to Europe. The material, if of wood or papier-machée, is first sized, polished, and varnished; it is then colored or painted in various devices, and afterwards covered with a highly transparent varnish or lacquer, which is ultimately dried at a high temperature, and carefully polished.

JAPANNED TEA-TRAYS, were made by Clay, by uniting sheets of paper with wheaten flour and glue boiled together. They were then rubbed with towels, from the centre to the edges, and dried in a stove before another sheet was laid on.

JAPAN, FOR TIN WARE.—In 6 oz. of oil of lavender dissolve 2 oz. of copal and 1 dr. of camphor, and mix with 8 oz. of oil of turpentine.

JAPAN PAINTING, is effected by colors prepared in varnish. It is finished with a coating of seed-lac varnish, made of 3 oz. of clean seed-lac, dissolved in a pint of rectified spirits of wine. This is laid on by single coats, with the brush, and each separately dried to the number of five or six coats. It is subsequently polished with a rag dipped in powdered rotten-stone, and finished with oil. In white grounds, fine putty or whiting should be used.

JAPAN WAX. Under this name different kinds of white wax are met with, the origin of which are a Japan plant, *Rhus Succedanea*. It is softer, more brittle, and fatty, than beeswax, easily kneaded, and melts between 40° and 42° C. It contains twice as much oxygen as beeswax, and has a different composition, consisting of palmitic acid, united with oxide of glyceryle. It is easily bleached with nitric acid.

JARGON. A hard gem brought from the East Indies, in the form of thin plates, which appear to be split from pebbles. They are of different colors, white, black, yellow, and brown, about as hard as sapphire; and as they have a great resemblance to the diamond, they are substituted instead of it in jeweller's work. In this stone, Klaproth discovered the earth called zircon.

JASPER, an opaque flint, which resembles dry clay. It is capable of a fine polish, and its color is generally reddish, or green, or striped; but it is also found blue, gray, or whitish. Its specific gravity is from 2·58 to 2·778.

It is infusible alone with the blowpipe; but it melts with *borax* or *microcosmic salt*, without any effervescence. Fire increases its hardness.

It is composed of *siliceous earth*, united to alumine very full of iron. Daubenton mentions 15 varieties.

JELLY, VEGETABLE, of ripe currants and other berries, is a compound of mucilage and acid, which loses its power of gelatinizing by prolonged ebullition.

JELLY, ANIMAL. (*See* GELATINE, GLUE, and ISINGLASS.)

JET, a species of pitch-coal or glance-coal, which, being found abundantly in a beautiful compact form, in the valley of Hers, arrondissement of Pamiers, department of the Arriège, has been worked up extensely there from time immemorial, into a multitude of ornamental articles. With this black lignite, buttons, crosses, rosaries, necklaces, ear-drops, bracelets, waist-buckles, &c., are made, which were at one time much worn by ladies for mourning dresses. The greater number of these ornaments are fashioned upon grindstones which turn in a horizontal direction, and are kept continually wet; others are turned at the lathe, or shaped by files.

In England, about 40 years ago, this manufacture employed from 1000 to 1200 operatives; at present it gives bread to only 60. This falling off may be ascribed to the successful imitation of the jet articles by those of black glass, which are equally beautiful, and not nearly so apt to lose their polish by use.

JET D'EAU. A fountain which throws up water to some height in the air. According to the theory of hydrostatics, the velocity with which water issues from an orifice is equal to that which would be acquired by a heavy body in falling through a height equal to the difference between the levels of the orifice and the fountain head; whence, if the resistance of the air and other impediments were removed, the height of the jet would be equal to that of the surface of the reservoir. Among the causes which prevent the jet from obtaining the height which theory assigns to it, the following are the principal: 1. The resistance of the air, which is proportional nearly to the square of the velocity. 2. The friction against the sides of the pipe and the orifice through which the water issues. 3. The velocity of the particles diminishing at every instant as they ascend, the lower particles of the ascending column press against those next above them; and the pressure being by the nature of fluids communicated in all directions, the consequence is, that the column is enlarged and proportionally shortened. 4. The water at the top of the jet does not fall off instantaneously when its velocity is destroyed; it rests for a moment at the top of the column, where its weight opposes an obstacle to the particles next succeeding, which retards their velocity, and this retardation is communicated to the whole column. This last obstacle may be avoided by slightly inclining the jet from the vertical; and it is found by experience that a jet so inclined plays higher than one quite upright, though the effect is thereby rendered less pleasing. It is necessary that the diameter of the adjutage or orifice be considerably less than that of the pipe. (See *Desagulier's Experimental Philosophy*; Mariotte, *Mouvement des Eaux*.)

JOGGLE JOINTS. The joints of stones or other masses indented in such a way that the adjacent stones fitting into the indentations are prevented from being pushed away from each other by any force perpendicular to the pressures by which they are thus held together.

JOGGLE PICA. In architecture a truss-post whose shoulders and sockets receive the lower end of the struts.

JUJUBE. The fruit of the *Rhamnus zizyphus*: it resembles a small plum, and is occasionally used as a sweetmeat. What is sold under the name of *jujube paste* professes to be the dried jelly of this fruit, but is, in fact, a mixture of gum arabic and sugar slightly colored.

JUNIPER BERRIES. The fruit of the *Juniperus communis*. They are used in medicine as a diuretic; but their principal consumption is in flavoring gin. When distilled with water they yield an essential oil, upon which their peculiar flavor depends. The resin of this tree is called juniper gum or sandarach, and is occasionally used in varnishes. When powdered it is used under the name of *pounce*, to prevent ink sinking into paper from which writing has been erased.

KALI, a maritime plant, from the ashes of which a considerable quantity of soda is obtained by lixiviation. By boiling the plant in water, and evaporating the decoction, a considerable quantity of sea-salt may be obtained.

The word Kali, and Alkali originally, had a similar meaning. The latter term is now applied to a class of bodies having peculiar properties, while the term kali is mostly confined to potash, the most active of the class of alkalies. The metal potassium is sometimes called kalium, and the symbol is always written with the initial letter K.

KAOLIN, porcelain earth, is an earthy, pure white, grayish or milk white substance, easily pulverized, and mixed with particles of quartz and feldspar. It is the most important material for making porcelain. Beds of pretty pure Kaolin have been found in the neighborhood of Lake Champlain, and scattered through the New-England states and that of New-York, in the valleys of the primary districts. It is clay in its pure and most original form, and is the prototype of all other clays. Kaolin is produced by the action of the atmosphere upon certain minerals belonging to the feldspar class, as spodumene and porcelain spar. Besides the silicate of alumina (pure clay) of the feldspar, porcelain also contains undecomposed debris of rocks, silicates of magnesia and lime, and free silicic acid. These impurities are sometimes as much as 16 per cent. Out of 31 analyses made by Brogniart and Malaguti, 18 consisted of alumina and silica in equivalent proportions, the remainder containing an excess of silica. In 100 parts various samples contained the following ingredients:—

Kaolin from— According to—	St. Yrieux. Berthier.	Passau. Fuchs.	Halle. Bley.
Silica	47·09	43·65	89·62
Alumina	86·41	85·93	45·00
Potash	1·56	....	....
Magnesia	2·94	....	8·32
Lime	...	0·88	0·07
Oxide of Iron	...	1·00	....
Oxide of Manganese	...	...	0·19
Water	12·00	18·50	10·

The decomposition of the feldspar out of granite affords a very good Kaolin or China Clay.

KEEL. The principal piece of timber of a ship, usually first laid on the blocks in building. If we compare the body of a ship to the human skeleton, the keel seems to resemble the backbone, and the timbers the ribs. It is generally composed of several thick pieces of wood placed lengthways, which, after being scarfed together, are bolted and clenched upon the upper side. *Keelage* signifies the duty paid by a ship on coming into port.

The keel is generally elm, except the after-piece, which, on account of its being often wet and dry, is sometimes oak, especially when the ship is expected to be a great while in building. The number of pieces in the keel is not very material, so that it gives good shift to the keelson and the mainmast. The keel is scarfed with a hook in the middle, which should lay very close, it being designed on purpose to bear the strain of calking the butts, that the bolt in the scarf may not be strained. The keel should not be tapered much, either forward or aft at the upper part, and from thence it is to be bearded away at the lower edge; for, when the dead-wood is trimmed, especially abaft, being frequently very thin, it is with much difficulty that the dead-wood can be securely bolted.

The speed of a vessel does not depend so much upon the form of the bow as it does on the depth to which it is immersed in the water. In the case of a frigate drawing 17 feet water, and another frigate of the same burthen drawing 11 feet, the last will have a body of six feet less fluid to penetrate, to make her hold a good wind, while the first has six feet perpendicular depth of her hull depressed, being about one-third of her real size. Therefore, she has a body of water to displace, and to force herself through, equal to the difference between 11 and 17. The resistance of the fluid also increases in proportion to the depth. Vessels in the coal-trade draw one-third less water than any other of British construction; yet, when employed as transports, they sail as fast as any others; and, before the wind, in ballast, or half loaded, frequently beat the royal navy. When closed hauled on a wind they drop to leeward; but, if they were furnished with *sliding keels*, they would be superior to all the other English vessels. The Dutch have vessels built almost flat, but all these have *lee-boards*, by the assistance of which they sail as fast as any that navigate the North Sea.

Ships, or vessels of the larger classes, should always be so constructed as to sail on, or nearly on an even keel,—that is, so that when the ship is trimmed for sailing, she should have her keel *parallel* to the surface of the water; therefore, as much as the effort of the wind on the sails and mast, in forcing the ship through the water, has a constant tendency to *depress* the bow, so much should the ship be properly trimmed at the stern.

A sharp-built ship sinks under its cargo so fast, that by the time it comes to its bearings, it is frequently not loaded. Those having flat and long floors, on the other hand, sink slowly; and after having taken in the quantity they measure, will have, frequently, plenty of room, and remain high out of the water. The only objection to the latter is, the unfitness of a flat-floored vessel to hold a good wind, but this difficulty is removed by the adoption of *sliding keels.* The same principle, which causes flat-floored vessels to sail faster before the wind, to carry a larger cargo, and draw less water, operates with equal force in rendering them easy at anchor. Their form, with the fulness of their body fore and aft, enables them to rise and fall, according to the lift of the sea, while sharp and clean-built ships pitch with the utmost violence, frequently with such force as to endanger the masts; to say nothing of the strain which the tremendous jerks give the hull and the injury of the anchors and cables.

The use of sliding keels is known, by actual experience, to be of the greatest importance. In fresh breezes, or in light winds, it is totally immaterial how much sail is set, or how it is disposed; *since the act of raising or lowering the keels will immediately counteract the inconvenience that might otherwise arise from carrying too much sail, either forward or aft.* The most trifling practice will render the navigators perfectly acquainted with their use, and the easy steerage of this ship will convince him of their advantage. In a gale of wind it is necessary that the main and fore-keels should be hauled close up, and the stern-keel let down to such depth as shall be found necessary to make the vessel steer perfectly easy.

KELP. A common term for sea-weed or vraic, which consists of different species of *Fucus* (varec). In a strict sense, the term kelp is confined to the produce of sea-weeds when burned, which consists of alkaline ashes used in the manufacture of glass and soap. It has been recently found, however, that the alkali required for these purposes can be obtained more abundantly from sea-salt, and kelp is at present chiefly used as a manure. For this purpose it is eagerly sought after by all farmers on the sea-coast, and especially by those who have dry soils, the salt contained in the kelp being a powerful absorbent of moisture from the atmosphere. It has lately acquired much importance as a source of *iodine.*

The species used in the manufacture of this article grow attached to rocks, between high and low water mark. On the Scottish coast it is cut close to the rocks, during the summer season, and spread, and turned to dry. It is then stacked and sheltered, till covered with white saline efflorescence, and is then ready for burning, in a round pit or kiln, lined with brick or stone, about 2 ft. wide, 8 to 18 long, and from 2 to 3 deep. The bottom is covered with brush, upon which a little dried sea-weed is scattered, and fire is applied at one extremity; the sea-weed is now thrown on gradually, as fast as the combustion reaches the surface. After the whole is burnt, the mass gradually softens, beginning at the sides, when it should be slowly stirred up with a heated iron bar, and incorporated till it acquires a semi-fluid consistence. This part of the process requires considerable dexterity; and, if the mass continues dry, a little common salt should be thrown on it as a flux. When cold it is broken up, and is ready for sale.

Kelp contains but 2 or 8 per cent. of carbonate of soda, while Spanish barilla often contains 20 or 30. One of the products is iodine.

The use of soda, in general, is the same with that of potash, but it is indispensable in making plate and ground glass and hard soaps, and consumed in immense quantities by soap-boilers, bleachers, and glass-makers.

It is well known that the shores of the sea, and salt-marshes, as well as the margins of interior salt-lakes and salines, and, in general, all places to which water holding salt gains access, are inhabited by peculiar plants. In these maritime plants, soda *replaces* the potash, which is always present in plants growing in ordinary situations, and if they are removed to a distance from the sea-shore, they gradually lose their soda, and acquire potash in its stead. The barilla obtained in France from the *salicornia annua* yields 14 or 15 per cent. of soda.

The Highland Society of Scotland has published the following account of the manufacture of 115 tons of kelp in Harris. It was from cut-ware of two years' growth, in equal parts of *lady-ware,* which grows between the spring and neap high tides;

bell-ware, between high and low neap tides; *black-ware*, low water, spring and neap. It is cut with a strong reaping-hook. Sand and mud is washed off, and it is spread by day, and cocked by night. Then put into large cocks, and left to heat for six or eight days. It is burnt on a dry day, and a good breeze. The kilns are of hard stones, with turf outside, from 15 to 18 feet long, 2½ ft. broad and 2 feet high. Straw or heather is laid over this, set on fire, and dry-ware added on the top by degrees till the whole is in ashes. If it cakes, it must be raked. When all is burned, it has the appearance of a semi-vitrified solid. It is then broken into large lumps, and kept covered until it is put up in the cask for shipment. The following two analyses of kelp, one from Cherbourg, made by Girardin, and the other from Spain, made by Richardson, show it to be made up mainly of sulphate and chloride of potassium, and chloride of sodium, or common salt.

	Cherbourg	Spain.
Sulphate potash	42·54	15·85
Chloride potassium	19·64	10·55
Chloride sodium	25·38	68·35
Carbonate of soda	3·71	traces
Sulphate lime	....	1·10
Insoluble matter	·73	....
Iodine compounds	traces	....
Water	8·	4·00
	100·00	100·00

KERASOPHANY. A new art has been discovered in Berlin, which consists in making pictures of a material, the principal ingredient of which is wax, in imitation of transparent ones made in porcelain. To be seen, the picture must be placed between the observer and the light. The ingredients used with the wax destroy its brittleness, and it withstands a heat of more than one hundred and fifty degrees Fahrenheit.

KERMES. An insect found in many parts of Asia and the south of Europe; the *Coccus ilicis* of Linnæus. They were long taken for the seeds of the tree on which they live, and hence called *grains of kermes*. They are used as a red and scarlet dye, but very inferior to cochineal. Previously to the introduction of cochineal, by which it is now nearly wholly superseded, kermes had been the most esteemed drug for dyeing scarlet from a remote period of antiquity. Cloths dyed with kermes are of a deep-red color; and though much inferior in brilliancy to the scarlet cloths dyed with real Mexican cochineal, they retain the color better and are less liable to stain. The tapestries of Brussels and other parts of Flanders, which have scarcely lost any thing of their original brilliancy, even after a lapse of 200 years, were all dyed with kermes.

The principal varieties of kermes are the *coccus quercus*, the *coccus polonicus*, the *coccus fragariæ*, and the *coccus uva ursi*.

The *coccus quercus* insect lives in the south of Europe upon the kermes oak. The female has no wings, is of the size of a small pea, of a brownish-red color, and is covered with a whitish dust. From the middle of May to the middle of June the eggs are collected, and exposed to the vapor of vinegar, to prevent their incubation. A portion of eggs is left upon the tree for the maintenance of the brood. In the department of the Bouches-du-Rhone, one-half of the kermes crop is dried. It amounts annually to about 60 quintals or cwts., and is warehoused at Avignon.

The kermes of Poland, or *coccus polonicus*, is found upon the roots of the *scleranthus perennis* and the *scleranthus annuus*, in sandy soils of that country and the Ukraine. This species has the same properties as the preceding; one pound of it, according to Wolfe, being capable of dyeing 10 pounds of wool; but Hermstaedt could not obtain a fine color, although he employed five times as much of it as of cochineal. The Turks, Armenians, and Cossacks, dye with kermes their morocco leather, cloth, silk, as well as the manes and tails of their horses.

The kermes called *coccus fragariæ*, is found principally in Siberia, upon the root of the common strawberry.

The *coccus uva ursi* is twice the size of the Polish kermes, and dyes with alum a fine red. It occurs in Russia.

Kermes is found not only upon the *lycopodium complanatum* in the Ukraine, but upon a great many other plants.

Good kermes is plump, of a deep-red color, of an agreeable smell, and a rough and pungent taste. Its coloring matter is soluble in water and alcohol; it becomes yellowish or brownish with acids, and violet or crimson with alkalies. Sulphate of iron blackens it. With alum it dyes a blood-red; with copperas an agate gray; with copperas and tartar, a lively gray; with sulphate of copper and tartar, an olive green; with tartar and salt of tin, a lively cinnamon yellow; with more alum and tartar, a lilach; with sulphate of zinc and tartar, a violet.

Scarlet and crimson dyed with kermes, were called *grain colors*; and they are reckoned to be more durable than those of cochineal, as is proved by the brilliancy of the old Brussels tapestry.

Hellot says that previous to dyeing in the kermes bath, he threw a handful of wool into it, in order to extract a blackish matter, which would have tarnished the color. The red caps of the Levant are dyed at Orleans with equal parts of kermes and madder; and occasionally with the addition of some Brazil wood.

Cochineal and lac-dye have now nearly superseded the use of kermes as a tinctorial substance, in England.

KERMES MINERAL. A name given by the old chemists to the hydrosulphuret of antimony, in consequence of its reddish color. It may be obtained perfectly pure, by diluting the proto-chloride of antimony with solution of tartaric acid, and precipitating the metal with sulphureted hydrogen; or by exposing the finely levigated native sulphuret to a boiling solution of carbonate of potash for some time, and filtering the liquor while boiling hot. The kermes falls down in a brown-red powder, as the liquor cools.

KETCHUP, or CATSUP. A liquor used as a substitute for gravy. That made from the Tomato and Mushroom is most common. They can scarcely be called judicious mixtures, but rather an incongruous medley of strong tasting substances and spices, such as garlic, shallot, horse-radish, lemon-peel, beer, wine, mustard, anchovy, and spice. Mushroom catsup is usually made by adding the grosser part of the mushrooms beaten up into a pulp, to a decoction of spice and salt—properly, the expressed juice of the mushroom should be preserved in spice liquor.

KILLAS. A name given to clay slate by Cornish miners.

KILN. The various forms of furnaces and stoves, by which strong heat may be applied to bodies, are so called. Thus there are brick kilns, lime kilns, malt kilns, and pottery kilns. Under the head of LIMESTONE, MALT, and POTTERY, different forms of kiln are noticed.

KINIC ACID. A peculiar acid found in Cinchona bark by Vauquelin.

KINO. An extract obtained from the *Nauclea gambir*, a shrub growing at Sumatra and in the Islands of the Indian Ocean. It is of a red brown color, has a styptic taste, and consists chiefly of tannin. It is only used as an astringent in medicine.

KIRSCHWASSER, is an alcoholic liquor by the fermentation and distillation of bruised cherries. In Switzerland and Germany it is the morello cherry which is used. When ripe it is black, and has an unusually large kernel: the fruit is snatched off the trees, and all kinds thrown into tubs and crushed either by hand or with a beater. These materials are allowed to ferment, and when this is completed it is transferred to a still covered with verdigris dust. The whole is conducted in the rudest way possible. The liquor has accordingly a rank smell, and is injurious to health from the empyreumatic oil and prussic acid it contains.

KEY-BOARD. In music, the series of levers in a keyed instrument, as a pianoforte, organ, or harpsichord, upon which the fingers press to produce percussion of the strings, or in the organ the opening of valves. It consists of short black and long white keys.

KEYSTONE. The middle voussoir in the arch of a bridge, or the archstone in the crown or immediately over the centre of the arch. The length of the keystone, or thickness of the archivolt at top, is allowed to be about 1-15th or 1-16th of the span by the best architects.

KREASOTE. See CREOSOTE.

KYANIZING. That process of preserving vegetable fibre recommended by the late Mr. Kyan, of New-York. It consisted in the complete soakage and penetration into the timber of a solution of bichloride of mercury (corrosive sublimate). This salt was proposed as a protective agent against the attack of *dry rot*, which renders wood so utterly worthless after a few years. It was at one period much used in the British navy. (*See* WOOD, *preservation of*)

LABORATORY. The workshop of a chemist. Some laboratories are intended for private research, and some for the manufacture of chemicals on the large scale. Hence it is almost impossible to give a description of the apparatus and disposition of a laboratory which would be generally true of all. A manufacturing laboratory necessarily occupies a large space, while that of the scientific man is necessarily limited to a peculiar line of research. Those who study in organic chemistry have different arrangements from that of the mineral analyist.

A laboratory is furnished with a fixed

furnace, and sundry auxiliaries and portable furnaces. It ought also to contain blow-pipes and galvanic troughs, with crucibles, matresses, retorts, flasks, vessels, and bottles; also a pestle and mortar, a vice, a lathe, and carpenters' tools; a pneumatic trough, a sink for water, tables, drawers, and shelves; with thermometers, a barometer, pyrometer, hydrometer, Argand's lamps, Wollaston's scale, weights and measures, &c. It requires also a small stock of tests and test-paper, and of sulphuric, nitric, and acetic acids; with nitre, soda, ammonia, alcohol, &c., &c.; and especially pasteboard and wire masks, and a stout apron for the stomach and abdomen. The cost varies from $200 to $2,000.

The expense of fitting up a laboratory to furnish articles of common consumption is very small. The instruments indispensably necessary are—an alembic, with a refrigerator and portable furnace. If the operator should not choose to go to the expense of the alembic and its apparatus, a succedaneum may be found for them in a sand-bath or sand-heat, with retorts, under suitable precautions.

Sand-heat is usually formed, in the large way, of an oblong shape, having bricks and mortar for its walls, plates of iron upon which to lay the sand, and around the top a ledge, of about six or eight inches deep, of free-stone, to retain the sand. Beneath the plates of iron is a wide flue, at the bottom of which is an iron grating, upon which grating is laid the fire. The fire is, of course, when kindled, enclosed by a door, as in other furnaces, at the end of the sand-heat; a flue communicates with a chimney, to carry off the smoke. The sand is commonly of the depth of six or eight inches; but the quantity and depth depend upon the size of the vessels.

A *retort* is a vessel usually made of green or other glass, and may be made to hold from half a pint to eight or more gallons. It has a long narrow neck, which is so bent, that when the retort is placed with its contents in a sand-bath, or over a fire, it has a gentle inclination, and will conduct whatever liquid is condensed in it, into a *glass receiver*, which is placed on a bench beside the sand-heat; the receiver is luted to the neck of the retort, either by a caoutchouc skin, which is the neatest way, or by some other lute. A variety of chemical processes are thus conducted: the vapors raised by the heat being condensed in the neck of the retort, and cooled down in the receiver, (which is usually about the size of a retort,) by the large surface which it presents to the air. With Florence flasks and bent tubes fitted with cork many operations requiring retorts may be used; and even small glass tubes may supplant these latter in the more delicate applications.

On this, as on many other subjects, more is learnt in half an hour, by actual inspection, than by half a volume of description.

There are some very well-appointed laboratories in this country; amongst others, that in the Lawrence Scientific School, Harvard University, Cambridge, Mass., and those in Philadelphia are prominent.

LAC. Lac-dye, is produced by the puncture of an insect called the Cocus Lacca, upon the branches of several plants as varieties of the ficus, rhamnus, and the croton. It is the female insect which punctures the twig, which then becomes surrounded with a resinous juice which hardens and has a crystalline fracture. This constitutes the *stick-lac* of commerce; it is of a red color, more or less deep and transparent.

According to Franke, the constituents of stick-lac are, resin, 65·7; substance of the lac, 23·2; coloring matter, 0·6.

Seed-lac. When the resinous concretion is taken off the twigs, coarsely pounded, and triturated with water in a mortar, the greater part of the coloring matter is dissolved, and the granular portion which remains, being dried in the sun, constitutes *seed-lac*. It contains, of course, less coloring matter than the stick-lac, and is much less soluble. John found in 100 parts of it, resin, 66·7; wax, 1·7; matter of the lac, 16·7; bitter balsamic matter, 2·5; coloring matter, 8·9; dun yellow extract, 0·4; envelopes of insects, 2·1; laccic acid, 0-0; salts of potash and lime, 1·0; earths, 6·6; loss, 4·2.

In India the *seed-lac* is put into oblong bags of cotton cloth, which are held over a charcoal fire by a man at each end, and, as soon as it begins to melt, the bag is twisted so as to strain the liquefied resin through its substance, and to make it drop upon smooth stems of the banyan tree. In this way, the resin spreads into thin plates, and constitutes the substance known in commerce by the name of *shellac*.

The Pegu stick-lac, being very dark-colored, furnishes a shellac of a corresponding deep hue, and therefore of inferior value. The palest and finest shellac is brought from the northern *Circar*. It contains very little coloring matter. A stick-lac of an intermediate kind comes from the Mysore country, which yields a brilliant lac-dye and a good shellac.

Lac-dye is the watery infusion of the ground stick-lac, evaporated to dryness, and formed into cakes about two inches square, and half an inch thick. Dr. John found it to consist of coloring matter, 50; resin, 25; and solid matter, composed of alumina, plaster, chalk, and sand, 22.

Dr. Macleod, of Madras, prepared a very superior lac-dye from stick-lack, by digesting it in the cold in a slightly alkaline decoction of the dried leaves of the *Memecylon tinctorium*. This solution being used along with a mordant, consisting of a saturated solution of tin in muriatic acid, was found to dye woollen cloth of a very brilliant scarlet hue.

The cakes of *lac-dye* imported from India, stamped with peculiar marks to designate their different manufacturers, are now employed exclusively in England for dyeing scarlet cloth, and are found to yield an equally brilliant color, and one less easily affected by perspiration than that produced by cochineal. When the lac-dye was first introduced, sulphuric acid was the solvent applied to the pulverized cakes, but as muriatic acid has been found to answer so much better, it has entirely supplanted it. A good *solvent* (No. 1) for this dye-stuff may be prepared by dissolving three pounds of tin in 60 pounds of muriatic acid, of specific gravity 1·19. The proper *mordant* for the cloth is made by mixing 27 pounds of muriatic acid of sp. grav. 1·17, with 1½ pounds of nitric acid of 1·19; putting this mixture into a salt-glazed stone bottle, and adding to it, in small bits at a time, grain tin, till 4 pounds be dissolved. This solution (No. 2) may be used within twelve hours after it is made, provided it has become cold and clear. For dyeing, three quarters of a pint of the solvent (No 1) is to be poured upon each pound of the pulverized lac-dye, and allowed to digest upon it for six hours. The cloth, before being subjected to the dye bath, must be scoured in the mill with fullers' earth. To dye 100 pounds of pelisse cloth, a tin boiler of 300 gallons capacity should be filled nearly brimful with water, and a fire kindled under it. Whenever the temperature rises to 150° Fahr., a handful of bran and half a pint of the solution of tin (No. 2) are to be introduced. The froth, which rises as it approaches ebullition, must be skimmed off; and when the liquor boils, 10½ pounds of lac-dye, previously mixed with 7 pints of the solvent No. 1, and 3½ pounds of solution of tin No. 2, must be poured in. An instant afterwards, 10½ pounds of tartar, and 4 pounds of ground sumach, both tied up in a linen bag, are to be suspended in the boiling bath for five minutes. The fire being now withdrawn, 20 gallons of cold water, with 10½ pints of solution of tin, being poured into the bath, the cloth is to be immersed in it, moved about rapidly during ten minutes; the fire is to be then rekindled, and the cloth winced more slowly through the bath, which must be made to boil as quickly as possible, and maintained at that pitch for an hour. The cloth is to be next washed in the river; and lastly, with water only, in the fulling mill. The above proportions of the ingredients produce a brilliant scarlet tint, with a slightly purple cast. If a more orange hue be wanted, white Florence argal may be used, instead of tartar, and some more sumach. Lac-dye may be substituted for cochineal in the orange-scarlets; but for the more delicate pink shades, it does not answer so well, as the lustre is apt to be impaired by the large quantity of acid necessary to dissolve the coloring matter of the lac.

Shellac, by Mr. Hatchett's analysis, consists of resin, 90·5; coloring matter, 0·5; wax, 4·0; gluten, 2·8; loss, 1·8; in 100 parts.

The resin may be obtained pure by treating shellac with cold alcohol, and filtering the solution in order to separate a yellow gray pulverulent matter. When the alcohol is again distilled off, a brown, translucent, hard, and brittle resin, of specific gravity 1·139, remains. It melts into a viscid mass with heat, and diffuses an aromatic odor. Anhydrous alcohol dissolves it in all proportions. According to John, it consists of two resins, one of which dissolves readily in alcohol, ether, the volatile and fat oils; while the other is little soluble in cold alcohol, and is insoluble in ether and the volatile oils. Unverdorben, however, has detected no less than four different resins, and some other substances, in shellac. Shellac dissolves with ease in dilute muriatic and acetic acids; but not in concentrated sulphuric acid. The resin of shellac has a great tendency to combine with salifiable bases; as with caustic potash, which it deprives of its alkaline taste.

This solution, which is of a dark red color, dries into a brilliant, transparent, reddish-brown mass; which may be redissolved in both water and alcohol. By passing chlorine in excess through the dark-colored alkaline solution, the lac-resin is precipitated in a colorless state. When this precipitate is washed and dried, it forms, with alcohol, an excellent pale-yellow varnish, especially with the addition of a little turpentine and mastic.

With the aid of heat, shellac dissolves readily in a solution of borax.

LACE. Is a species of net-work made of silk, thread, or cotton, upon which in old times patterns were embroidered by the needle after its construction. It is now, however, almost always formed during the construction. The best laces are made at Mechlin, Brussels, Antwerp, Ghent, and Valenciennes. In the British dominions, at Nottingham, and Limerick.

The real lace, such as was worn by the dowagers of the last century, is formed principally of *flax* thread, and is wholly worked by hand, not only in the decorative parts, but in the mesh-work ground itself. The bobbin-net of modern times is made of *cotton* thread; the meshes being made wholly by machinery; and the figured device (if any) being effected sometimes by the same machine and at the same time as the ground, and sometimes by a kind of embroidery or tambour-work. The silk net, such as the material of which black veils are sometimes made, is, as its name imports, made of *silk* thread, and is formed by machinery very nearly on the same principle as bobbin-net.

At what period and in what country this elegant material was originally first wrought for dress cannot perhaps be easily determined. It has been supposed that Mary de Medici was the first who brought lace into France from Venice, where, and in the neighboring states of Italy, lace seems to have been long previously worn. It is recorded that lace-making was introduced into England by some refugees from Flanders, who settled near Cranfield, now a village on the west side of Bedfordshire, and adjoining Buckinghamshire; and it has been supposed that the first kind so made in England was that which is called *Brussels point*, the net-work being made by bone bobbins on a pillow, and the pattern and sprigs being worked with a needle.

The working of hand-made or "pillow lace" may be thus briefly described: The lace-maker sits on a stool or chair, and places a hard cushion on her lap. The desired pattern is sketched upon a piece of parchment, which is then laid down upon the cushion; and she inserts a number of pins through the parchment into the cushion, in places determined by the pattern. She is also provided with a number of small bobbins, on which threads are wound; fine thread being used for making the meshes or net, and a coarser kind, called *gimp* or *gymp*, for working the device. The work is begun at the upper part of the cushion by tying together the threads in pairs, and each pair is attached to one of the pins through the cushion. The threads are then twisted one round another in various ways, according to the pattern, the bobbins serving as handles as well as for store of material, and the pins serving as knots or fixed points, or centres, round which the threads may be twisted. The pins inserted in the cushion at the commencement are merely to hold the threads; but as each little mesh is made in the progress of the working, other pins are inserted, to prevent the threads from untwisting; and the device on the parchment shows where these insertions are to occur.

The pillow-made, or bone-lace, which formerly gave occupation to multitudes of women in their own houses, has, in the progress of mechanical invention, been nearly superseded by the bobbin-net lace, manufactured at first by hand-machines, as stockings are knit upon frames, but recently by the power of water or steam. This elegant texture possesses all the strength and regularity of the old Buckingham lace, and is far superior in these respects to the point-net and warp lace, which had preceded, and in some measure paved the way for it.

The threads in bobbin-net lace form, by their intertwisting and decussation, regular hexagonal holes or meshes, of which the two opposite sides, the upper and under, are directed along the breadth of the piece, or at right angles to the selvage or border. By the crossing and twisting of the threads, the regular six-sided mesh is produced, and the texture results from the union of three separate sets of threads, of which one set proceeds downwards in serpentine lines, a second set proceeds from the left to the right, and a third from the right to the left, both in slanting directions. These oblique threads twist themselves round the vertical ones, and also cross each other betwixt them, in a peculiar manner. In comparing bobbin-net with a common web, the perpendicular threads, which are parallel to the border, may be regarded as the warp, and the two sets of slanting threads, as the weft.

These warp threads are extended up and down, in the original mounting of the piece, between a top and bottom horizontal roller or beam, of which one is called the warp beam, and the other the lace beam, because the warp and finished lace are wound upon them respectively. These straight warp threads receive their contortion from the tension of the weft threads twisted obliquely round them alternately to the right and the left hand.

If we pursue the path of a weft thread, we find it goes on till it reaches the outermost or last warp thread, which it twists about; not once, as with the others, but twice; and then returning towards the other border, proceeds in a reverse direction. It is by this double twist, and by the return of the weft threads, that the selvage is made.

The ordinary material of bobbin-net is two cotton yarns, of from No. 180 to No. 250, twisted into one thread; but sometimes strongly twisted single yarn has been used. The beauty of the fabric depends upon the quality of the material, as well as the regularity and smallness of the meshes. The number of warp threads in a yard in breadth is from 600 to 900; which is equivalent to from 20 to 30 in an inch. The size of the holes cannot be exactly inferred from that circumstance, as it depends partly upon the oblique traction of the threads. The breadth of the pieces of bobbin-net varies from edgings of a quarter of an inch, to webs 12, or even 20 quarters, that is, 5 yards wide.

Bobbin-net lace is manufactured by means of very costly and complicated machines, called *frames*.

The bobbin of a net machine is a curious contrivance. The cotton is wound on to a bobbin or reel from the skeins by a winding machine, and thence transferred to the little apparatus of the bobbin-net machine. This apparatus is so minute that the whole of it, inclusive of the bobbin on which the cotton weft thread is wound, and the carriage or frame in which it is placed, is not thicker than the diameter of the meshes in the net to be made. This thickness is often not more than the one-thirtieth of an inch.

The bobbin consists of two thin disks of brass about an inch and a half in diameter, laid face to face, with a slight intervening space; and in this minute space the thread is wound, in quantity about fifty or sixty yards to each bobbin. The bobbin is then fitted into a kind of carriage, which conveys it between the threads of the warp, and at the same time allows the thread to be unwound from the bobbin: in short, the carriage is to the bobbin what the little boat of a shuttle is to the pin on which the weft-thread is wound.

No less than three thousand six hundred of such bobbins as are here described are sometimes used in one machine! Many of the machines are twenty quarters wide—that is, fitted to the manufacture of net five yards in width; and have twenty of these bobbins to the inch.

If the arrangement of such a machine be examined, it will be seen that the warp-threads are wound on a beam in the lower part of the machine, from which they ascend to the upper part. The warp is divided into two parcels (somewhat in the same manner as the warp of a common loom by the action of the treadles), and each parcel is susceptible of a reciprocating motion, alternately to the right and left. The weft-threads, wound on the bobbins, are fastened each at one end to the upper part of the machine; and the bobbins are suspended so as to have a backward and forward motion between the warp-threads, like so many clock pendulums, being guided between the warp-threads by a very curious piece of apparatus called a "comb." The principle of action, then, is this:—After the bobbins have been driven between the respective warp-threads, the warp is shifted a little on one side, so that, when the bobbins return, they pass through openings different from those which they traversed in the first instance; and by this means the weft-thread, unwinding from each bobbin in the course of its movement, becomes twisted around one of the warp-threads. After this has been repeated two or three times, the comb which carries the bobbins is itself shifted to and fro laterally, by which the bobbins are brought opposite to openings between the warp threads different from those to which they were before opposed. Herein lies the whole principle. According as the front layer of warp, or the hinder layer, or the comb carrying the bobbins, are shifted to and fro laterally, so does the weft-thread, as it becomes unwound from the bobbins, twist round the warp-threads during the passage of the bobbins across; a shifting, in one or other of several different ways, being effected immediately after each traverse of the bobbin. After a certain number of twistings have been effected, a series of points become inserted between the warp-threads, and temporarily hold up the knotted twists so as to form the meshes of the net.

It has been often said, and truly, that the bobbin-net machine is one of the most complicated which the ingenuity of man has ever devised; and it may therefore well be supposed that nothing more than the bare principle can be here exhibited. Perhaps it may assist the reader if we carry out our former supposition a little further. Let a series of strings be suspended from the ceiling in the two rows, with the lower ends of each row fastened to a horizontal bar: and let a number of small pendulums be suspended between the strings, and enabled to oscillate to and fro between them. Then, if after each traverse of the pendulums between the stretched threads, the rows, one or both, of threads be shifted a little on one side, so that the pendulums may return through openings different from those which they before traversed, we should have a system of movements somewhat analogous to those in the machine; and the strings by which the pendulums were suspended would be found to twist round the stretched vertical strings. If we further suppose that each row of strings is capable of being shifted independent of the other, and that the pendulum strings be fastened to a shifting bar near the ceiling, we might imitate in a rough way the series of movements by which net is made.

Not only is plain net made by these movements of the machine, but figured net also. In plain nets, all the bobbins are moved similarly at the one time; but in fancy nets, some are stationary, some pass between the warp threads, some are shifted laterally to the distance of one mesh, some to the distance of two or three meshes, some move to the right and some to the left. The warp-threads instead of being divided into two parcels, are divided into several, each of which is susceptible of the lateral movement independent of the others; it is by modifications of these lateral movements that all the numerous varieties of machine made lace or net are produced.

A rack of lace is a certain length of work counted perpendicularly, and contains 240 meshes or holes. In perfect lace the mesh is elongated a little in the direction of the selvage. The price of labor in making a rack 20 years ago was $1, it is now made for two cents; so great has been the improvement and economy in the manufacture, and this reduction of cost illustrates well the great capabilities of machinery. In Mr. Waterhouse's (of England) machine for manufacturing mechlin-lace, the number of warp-threads in the width alone is 4,700, and a corresponding number of bobbins or weft-threads are required, making a total of 9,400 threads: which represents the same number of bobbins, and are all kept in motion at the same time. In making pillow lace it requires as many hands as there are bobbins: for on the cushion one hand must wait for the other in order to obtain the register crossings of the threads. Some idea may be formed of the intricacy of the machinery and the ingenuity displayed in the arrangement. Some of the specimens woven by the machine were 26 yards long and 4 yards wide, and had 4 patterns woven in it. The number of motions or throws that would be required to produce a similar piece of lace by hand would amount to not less than 2,111,616,000.

LACKER, or LACQUER, is a varnish consisting chiefly of a solution of pale shell-lac in alcohol, tinged with saffron, annotto, or other coloring matters. The following are a few of the formulæ with the proportions:

LACKER. (*For metals and wood—a golden color.*) In 5 half-pints of alcohol dissolve 1 oz. of seed-lac, gum dragon, gamboge, and annotto, also 2 drs. of saffron; or, in 12 oz. of alcohol dissolve 1 lb. of turmeric, 2 oz. of annotto, and 2 oz. of shell-lac and juniper gum: or, in 2 pints and 4 oz. of alcohol dissolve ¼ dr. of saffron and of extract of red sanders, 1 dr. of gum dragon, 2 oz. of amber and of gamboge, and 3 oz. of seed-lac; or, in 1 pint 4 oz. of alcohol, dissolve 6 drs. of turmeric and 15 grs. of saffron; decant, and add 6 drs. of gamboge, 2 oz. of gum elemi and of gum sandarac, and 1 oz. of gum dragon and of seed-lac.

LACQUER FOR TIN. Take 8 oz. of amber, 2 oz. of gum-lac, melt them in separate vessels, and mix them well together; then add ¼ lb. of drying linseed-oil. Into a pint phial put half a pint of spirits of turpentine, and digest in it a little saffron; when the color is extracted, strain the liquor, and add gum tragacanth and annotto, finely powdered, and in small quantities at a time, till the required tone of color is produced; then mix this coloring matter with the first compound before prescribed, and shake them well together till a perfect union takes place. If this varnish be laid over silver-leaf or tin-foil, it will be difficult to distinguish it by the eye from gold. It is by a varnish of this kind that leather, paper, or wood, covered with silver-leaf, is made to appear as if it were gilded. The lacquer is also applicable to tin-plate articles, but small articles of finely-polished brass are usually coated with a thinner composition.

Lacquer for Brass or Silver. Take 2 oz. of seed-lac, 2 oz. yellow amber, 40 grs. dragon's blood, 30 grs. saffron, 40 oz. spirits of wine, and digest on a sand-bath. Strain through a fine cloth, and cork. Clean and burnish the buttons, heat them, and apply the lacquer.

Lac Spirit is made of muriatic acid (sp. gr. 1·19) 60 lbs.; tin 3 lbs., dissolved. It is used in dyeing with lac-dye; or, it may be made of aquafortis 28 lbs. and tin 4 lbs.; dissolved gradually and stirring frequently.

LACTIC ACID was first discovered by Scheele in buttermilk, in which it is abundant. It also exists in fresh milk. It does not crystallize, and forms with most bases, except zinc and magnesia, gummy salts. It has not, as yet, been turned to any useful purpose in the arts.

LACTOMETER is the name of an instrument for estimating the quality of milk, called also a *Galactometer*. The most convenient form of apparatus would be a series of glass tubes about 1 inch in diameter, and 12 inches long, graduated through a space of 10 inches, two-tenths of an inch, having a stop-cock at the bottom, and suspended upright in a frame. The average milk of the cow being poured in to the height of 10 inches, as soon as the cream has all separated at top, the thickness of its body may be measured by the scale; and then the skim milk may be run off below into a hydrometer glass, in order to determine its density, or relative richness in caseous matter.

LAKES. Under this title are comprised all those colors which consist of a vegetable dye, combined by precipitation with a white earthy basis, which is usually alumina. The general method of preparation is to add to the colored infusion a solution of common alum, or rather a solution of alum saturated with potash, especially when the infusion has been made with the aid of acids. At first only a slight precipitate falls, consisting of alumina and the coloring matter: but on adding potash, a copious precipitation ensues, of the alumina associated with the dye. When the dyes are not injured, but are rather brightened by alkalies, the above process is reversed; a decoction of the dye-stuff is made with an alkaline liquor, and when it is filtered, a solution of alum is poured into it. The third method is practicable only with substances having a great affinity for subsulphate of alumina; it consists in agitating recently precipitated alumina with the decoction of the dye.

Yellow lakes are made with a decoction of Persian or French berries, to which some potash or soda is added; into the mixture a solution of alum is to be poured as long as any precipitate falls. The precipitate must be filtered, washed, and formed into cakes, and dried. A lake may be made in the same way with quercitron, taking the precaution to purify the decoction of the dye-stuff with buttermilk or glue. After filtering the lake, it may be brightened with a solution of tin. Annotto lake is formed by dissolving the dye-stuff in a weak alkaline ley, and adding alum water to the solution. Solution of tin gives this lake a lemon yellow cast; acids a reddish tint.

Red lakes.—The finest of these is *carmine.*

This beautiful pigment was accidentally discovered by a Franciscan monk at Pisa. He formed an extract of cochineal with salt of tartar, in order to employ it as a medicine, and obtained, on the addition of an acid to it, a fine red precipitate. Homberg published a process for preparing it, in 1656. Carmine is the coloring matter of cochineal, prepared by precipitation from a decoction of the drug. Its composition varies according to the mode of making it. The ordinary carmine is prepared with alum, and consists of *carminium* (see Cochineal), a little animal matter, alumina, and sulphuric acid. See Carmine.

Carminated lake, called lake of Florence, Paris, or Vienna. For making this pigment, the liquor is usually employed which is decanted from the carmine process. Into this, newly precipitated alumina is put; the mixture is stirred, and heated a little, but not too much. Whenever the alumina has absorbed the color, the mixture is allowed to settle, and the liquor is drawn off.

Sometimes alum is dissolved in the decoction of cochineal, and potash is then added, to throw down the alumina in combination with the coloring matter;

but in this way an indifferent pigment is obtained. Occasionally, solution of tin is added, to brighten the dye.

A lake may be obtained from kermes, in the same way as from cochineal; but now it is seldom had recourse to.

Brazil-wood lakes. Brazil-wood is to be boiled in a proper quantity of water for 15 minutes; then, alum and solution of tin being added, the liquor is to be filtered, and a solution of potash poured in as long as it occasions a precipitate. This is separated by the filter, washed in pure water, mixed with a little gum water, and made into cakes. Or, the Brazil-wood may be boiled along with a little vinegar, the decoction filtered, alum and salt of tin added, and then potash-ley poured in to precipitate the lake. For 1 lb. of Brazil wood, 30 to 40 lbs. of water, and from 1½ to 2 lbs. of alum, may be taken, in producing a deep red lake; or the same proportions with half a pound of solution of tin. If the potash be added in excess, the tint will become violet. Cream of tartar occasions a brownish cast.

Madder lake. A fine lake may be obtained from madder, by washing it in cold water as long as it gives out color; then sprinkling some solution of tin over it, and setting it aside for some days. A gentle heat may also be applied. The red liquor must be then separated by the filter, and decomposed by the addition of carbonate of soda, when a fine red precipitate will be obtained. Or, the reddish brown coloring matter of a decoction of madder may be first separated by acetate of lead, and then the rose-red color with alum. Or, madder tied up in a bag is boiled in water; to the decoction, alum is added, and then potash. The precipitate should be washed with boiling water, till it ceases to tinge it yellow; and it is then to be dried.

The following process merits a preference:

Diffuse 2 pounds of ground madder in 4 quarts of water, and after a maceration of 10 minutes, strain and squeeze the grounds in a press. Repeat this maceration, &c., twice upon the same portion of madder. It will now have a fine rose color. It must be mixed with 5 or 6 lbs. of water and half a lb. of bruised alum, and heated upon a warm bath for 3 or 4 hours, with the addition of water, as it evaporates, after which the whole must be thrown upon a filter cloth. The liquor which passes is to be filtered through paper, and then precipitated by carbonate of potash. If the potash be added in three successive doses, three different lakes will be obtained, of successively diminishing beauty. The precipitates must be washed till the water comes off colorless.

Blue lakes are hardly ever prepared, as indigo, Prussian blue, cobalt blue, and ultramarine, answer every purpose of blue pigments.

Green lakes are made by a mixture of yellow lakes with blue pigments; but chrome yellows mixed with blues produce almost all the requisite shades of green.

LAMINABLE is said of a metal, which may be extended by passing between steel or hardened (chilled) cast-iron rollers. See IRON and MINT.

LAMPS were first invented by the Egyptians, from whom they passed to Greece and Rome. They were made of baked earth, iron, copper, silver, gold, and glass.

Ordinary lamps are only arrangements whereby materials (fat) which are fluid at common temperatures, as the oils, are consumed. The first object is to isolate as much of the oil as is required for the production of a flame. The simplest manner in which this can be effected, is that practised in the night-lights.

On a layer of oil covering the surface of the water there swims a brass cup, at the bottom of which is a small piece of glass tube, fitted tight by a cork. Although, before ignition, the oil rises in the interior of that tube above the level on the outside, yet, as the capillarity of the tube is annihilated by the heat, the fluid is actually depressed. To obviate this, the tube must be fixed so far below the surface of the oil, that the greater pressure of the oil without shall overcome the depression within. In this manner the insulated oil in the other end may be ignited, and continues to burn by itself. The conditions under which the oil is consumed, so far as the production of light is concerned, are most unfavorable, although the purpose of a night lamp is fully answered; for the flame is much too small for producing light for common purposes; and, if the size of the tube is increased, the oil will no longer burn, and the flame is too low down to lighten well the room. Both of these evils, particularly the latter, are avoided by the use of wicks. The common kitchen lamp is a slight improvement on this. The following are the essential points, which it has been the object of inventors to attain, sometimes singly, sometimes several at once.

1. To select such a form (section) of wick, that the quantity of decomposed oil, and the simultaneous supply of air, may stand in the relation to each other that the hydrogen and carbon may be consecutively consumed, and consequently no smoke produced.

2. To make the distance between the burning part of the wick and the surface of the oil as unchangeable as possible, in order that as much oil may be drawn up at last as at first.

3. To place the reservoir of oil in such a position that the shadow shall occasion little or no inconvenience. The use made of the lamp will regulate its form. Occasionally these cannot correspond.

Thus, the shadow of wall-lamps is unimportant, as the lamp covers its shadow; so the shadow of a study-lamp is not a fault, as it is only used by one person; yet still its prevention is an improvement.

4. To throw the light, radiating from the flame, by means of collectors and reflectors, from those parts where it is of little or no service, in the direction most required.

The requisites stated, under No. 1, have have been complied with in two ways; first, by controlling the access of air (the quantity of air); on the other by regulating the supply, and often by both at the same time. We have reference to that part of the lamp called the burner.

When there is much oil burned at the one point, the current of air supplied on the outside is never sufficient for burning away the oil completely, so as to produce only water and carbonic acid; on the contrary, an amount of carbon is deposited, owing to their not being oxygen enough to burn it fully away into carbonic acid: the flame soots. This great evil was to a certain extent remedied by the invention of the *Argand* lamp, called after Mr. Argand, who first produced it in 1784. The principle on which the superiority of the Argand lamp depends, is the admission of a larger quantity of air to the flame than can be done in the common way.

This is accomplished by making the wick of a circular form, by which means the current of air rushes through the cylinder on which it is placed, with great force, and along with that which has access to the outside, excites the flame to such a degree that the smoke is entirely consumed: thus both the light and heat are prodigiously increased. The combustion being exceedingly augmented by the quantity of air admitted to the flame, and what in common lamps is dissipated in smoke is here converted into brilliant flame. This lamp is now very much in use, and is applied not only to ordinary purposes of illumination, but also to that of a furnace for chemical operations, in which it is found to excel every other contrivance yet invented. It consists of two parts, a reservoir for the oil, and the lamp itself. The argand burner is made by forming a hollow cylindrical cavity, which receives the oil from the main body of the lamp, and at the same time transmits air through its axis or central hollow; in this cavity is placed a circular wick attached at bottom to a movable ring; this ring may be raised or depressed by rack and pinion work, or more commonly a screw, so that the height of the wick may be varied to regulate the size of the flame. On the outside is placed a glass chimney, which transmits a current of air on the same principles as a common smoke flue. When this lamp is lighted, the combustion is vivid and the light intense, owing to the free and rapid supply of air. The flame does not waver, and the smoke is wholly consumed. The brilliancy is increased if the air be made to impinge laterally against the flame. This is done by narrowing the glass chimney near the blaze, so as to bend the air inward, or by placing a metallic button over the blaze, so as to spread the internal current outward.

To avoid the shade occasioned in common lamps by the reservoirs for the oil being under the flame, various contrivances have been introduced, in which the reservoir is placed at a distance from the flame. In the *astral* and *sinumbra* lamps, the principal of which was invented by Count Rumford, the oil is contained in a horizontal ring, having a burner at the centre, communicating with the ring by two or more tubes placed like rays. The wick is placed a little below the level of the flame, and from its large surface affords a supply of oil for many hours. A small aperture is left for the admission or escape of the air in the upper part of the ring. When these lamps overflow, it is because the ring is not kept perfectly horizontal, or else because the air hole is obstructed—a circumstance which may be produced by filling the lamp too high with oil.

In all common lamps the oil box is above, and while it allows the oil to flow down upon the wick and keep it moist, it casts an objectionable shadow. To obviate this the oil box is placed in some lamps below, and the oil has to be *raised*; this involves ingenious but complicated apparatus.

Girard's hydrostatic lamp is constructed on precisely the same principles as the air chamber of a fire engine, or similar to the fountain of Hero (which see). The second illustration given under that article is an ideal lamp of Girard. The air vessel, air chamber, and connecting tubes are closely packed together. Its shape is inconvenient and limits its extended use.

In 1825 Thilorier, at Paris, invented a lamp in which the principle of the equilibrium of fluid pressure is made use of: if two fluids of different densities be placed in tubes connected at the bottom, they will balance each other at different heights, according to their respective densities. Thus, a column of mercury 1 inch high, will balance a column of sulphuric ether of 19 inches, or a column of oil 14 inches.

Thilorier used a solution of equal parts of white vitriol and water, which is 1½ times denser than oil. So that 10 inches of the zinc solution can balance 15·7 inches oil in the other tube. As the oil diminishes by burning, the zinc solution exerting its pressure upon it keeps it up to the original level. This lamp cannot well be moved or carried about, without fear of being extinguished.

In the mechanical lamp it is a pump which is used to raise the oil up. In *Carcel's* lamp the pump is worked by clock-wheel arrangement. The case for the works and space for the supply of oil are at the foot of the lamp: the stem of the lamp contains only the ascending tube, which separates above over the capital into a forked appendage or crutch, upon which rests the burner with its two concentric tubes. The burner and ascending tube form a space connected with the oil vessel by the pump. Three little pumps, termed *priest* pumps, are alternately acting, one being forcing, the second is sucking, and the third midway between the two. Motion is obtained by a spring wound up in a case and furnished with cogs, which act upon the wheel which works the pumps. This lamp burns well, but it is costly, is liable to get out of order, and cannot always readily be repaired.

Vapor lamps are those in which the fluid in the lamp is first vaporized, and the heat thus produced while burning tends to raise a fresh quantity of fluid up in the form of vapor. A little cup of spirits of wine, or a cloth soaked with the same, and surrounding the nozzle of the lamp, are the usual means of vaporizing the liquid, which is usually one part of turpentine mixed with 4 parts of alcohol of 90 per cent.

Solar lamps. The chief point in the construction of these lamps is the manner in which the air is caused to impinge upon the flame by the adaptation of a metallic or glass cone. This admits of a crude and cheap oil being used, which in other lamps would smoke.

A very beautiful kind of miniature *solar* lamp, for those who have much writing at night, is manufactured by Messrs Endicott and Sumner, N. Y. The light of one is equal to that of six sperm candles, and it can burn either oil or lard. A pound of lard lasts about twenty hours. The air is admitted to the flame all round it, inside and out, thus supplying it with plenty of oxygen, consequently there is no part of the flame blue, but all is a bright white light.

Whale oil is so thick and coarse when cold that it does not readily ascend the wick until heated.

Parker's economic or hot oil lamp was intended to obviate this, and has the oil vessel as a double cylinder, surrounding the upper part of the chimney. This latter is slightly curved outwards, so as to reflect the heat upon the oil vessel; the hot oil descends by the arm to the burner. A slide regulates and cuts off the supply, so that the oil vessel may be removed to be filtered. Care must be taken to *fill* the vessel with oil and allow no air to remain, as its expansion would make the oil overflow.

Camphene lamps.—Oil of turpentine is the liquid in these lamps. This substance is composed in 100 parts of 88·46 of carbon and 11·54 of hydrogen, which corresponds to the formula $C^{10}H^{8}$. This quantity of carbon is vastly above what is found in oils, and hence more air is requisite to burn it without sooting. This is accomplished by putting a button in the flame, and narrowing the glass at the point where the flame is thrown out. Sometimes the current of air which supplies the inner part of the flame is made to pass through the reservoir of turpentine, which becomes heated 10° or 15° above the temperature of the surrounding air.

A Platina lamp has been made by Mr. Merryweather, of Whitby, England, some years since. If a coil of small platina wire be placed around the wick of a spirit-lamp, and rendered red hot, the wire continues ignited for some time after the flame is blown out. The lower

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part is constructed of tin, in the body of which is a reservoir, large enough to contain a quart of alcohol. The bottom of the interior of the reservoir is concave, in order that the cotton wick may take up the last drop of the spirit. After the wick has been spread in the form of a coronet at the top of the lamp, a platina-wire cage, containing one piece of spongy platina, is to be pricked into the centre of the wick, and to be kept nearly in contact, but not to touch it. After the reservoir has been filled with alcohol, the wick is to be inflamed, and a minute afterwards the spongy platina becomes incandescent, when the flame of the wick is to be suddenly blown out, and the glass cover to be immediately placed over the platina. Without any further care or attention, the platina ball will keep ignited for thirteen or fourteen days and nights. If a tube is connected with a reservoir (containing a sufficient quantity of alcohol) and the bottom of the reservoir of the lamp, the platina ball may be kept ignited for years, as the spongy platina does not appear to be in the least deteriorated by being kept in a state of constant ignition. Two objections to this lamp, the expense of the alcohol and the odor are removed, since equal parts of alcohol and whisky answer as well as pure alcohol; or one-third of alcohol and two-thirds of whisky, which cost two cents for eight hours. Whiskey consists of 4 parts of alcohol and 3 parts of water. As a remedy for the second objection, an apparatus for condensing the vapor is made of tin, which is to be suspended from a nail in the wall. The glass tube of the lamp is to be inserted into the tin tube of the condensing apparatus, which will completely destroy the strong odor of the vapor, and the liquid is drawn off by the stop-cock at the side of the condenser.

Spirit-lamps are those used with cotton wicks and alcohol, and though the flame is slight the heat is intense, and its action on metals, &c., effective. As the alcohol approximates pure hydrogen, and has little carbon, it fixes much oxygen, which confers the heat, and there being no carbon, there is little light and no smoke; so that it forms no carbonic acid, and the gases are concentrated into aqueous vapor, giving out great heat for all chemical purposes. The heat is greatest just within the summit. Sometimes four burners are used, and one and two chimneys above each other, to place over the whole, allowing air to enter at the bottom, and in this case the highest degrees of heat are attained at an easy expense. The spirits or alcohol should have 0·85 spec. grav., *i. e.*, six pints should weigh five pints of water.

Spirit-lamps produce little flame but intense heat, since white light and flame result from the joint action of hydrogen and carbon. They are to be trimmed with a twisted cotton wick and alcohol, and they have the advantage of intense heat, without smoke or chemical combination with substances applied to them.

Sometimes several wicks are combined in a hollow cylinder, raised above the table, and a chimney may be added, with which it becomes a powerful furnace. The alcohol should be about ·84 or ·85. Pyroligneous ether may be substituted for alcohol, as cheaper in some countries.

Double wick, and Argand oil-lamps with separate rack-work, are very powerful and luminous, with free access of air.

To prevent the breaking of lamp-glasses by sudden heat, cut or scratch the base of the glass with a diamond, and afterwards sudden heat may be applied without danger.

LAMP OF DAVY consists of a common oil lamp, surmounted with a covered cylinder of wire gauze, for transmitting light to the miner without endangering the kindling of the atmosphere of fire-damp which may surround him; because carbureted hydrogen, in passing through the meshes of the cylindric cover, gets cooled by the conducting power of the metallic gauze, below the point of its ascension.

The frequency of explosions in coal mines in England led the Mining Board of that country to apply to Sir H. Davy in the hope he might be able to apply some means for its prevention. The experiments which he undertook for this end were numerous, and ended in the formation of this lamp. He found that the fire damp of the coal mine (carburetted hydrogen) was not explosive unless mixed with air, and that ten times its volume of air was the most explosive proportions; that even in these proportions it did not explode unless a body *in full ignition*—that is, *in flame*, were brought in contact with it. He also found that when the gas was inflamed and made to pass through metal tubes of small diameter, it cooled so much as not to set the surrounding gas on fire, and that it kept the inflamed and uninflamed portions perfectly distinct. On further experiment, he found that sections of tubes answered as well as tubes of any length, and hence a sheet of wire-gauze was equally efficient: he formed his safety lamp therefore of a tube of gauze, which prevented the inner flame of gas from spreading outwards into the great body of fire damp. It has been the means of saving many hundred lives; but miners will carelessly open it to have more light to work with, or to light their pipes, when if the fire-damp be in the passages an explosion must occur. Improvements have been made in Davy's lamp by Drs. Reid and Clanny, by substituting for the lateral wire gauze a glass shade closed at top with gauze.

The apertures in the gauze should not be more than 1-20th of an inch square. Since the fire-damp is not inflamed by ignited wire, the thickness of the wire is not of importance, but wire from 1-40th to 1-60th of an inch in diameter is the most convenient.

The cage or cylinder should be made by double joinings, the gauze being folded over in such a manner as to leave no apertures. When it is cylindrical, it should not be more than two inches in diameter; because in larger cylinders, the combustion of the fire-damp renders the top inconveniently hot; a double top is always a proper precaution, fixed half or three quarters of an inch above the first top.

The gauze cylinder should be fastened to the lamp by a screw of four or five turns, and fitted to the screw by a tight ring. All joinings in the lamp should be made with hard solder, as the security depends upon the circumstance that no aperture exists in the apparatus larger than in the wire gauze.

LAMPBLACK. Finely divided charcoal. It is the soot obtained by the imperfect combustion of resin of turpentine; this is burned in chambers hung with old sacking, upon which the smoke collects, and is from time to time scraped off. It contains about 20 per cent. of peculiar resinous products, water, and saline matter.

LAMPIC ACID. A term given by Mr. Daniell to the acid produced by the slow combustion of the vapor of alcohol and ether in the lamp without flame: he has since ascertained that it is acetic acid modified by the presence of a peculiar hydrocarbon.

LAND SPRINGS. Land springs are sources of water which only come into action after heavy rains; while constant springs, which derive their supplies from a more abundant source, flow throughout the year. All springs owe their origin to rains. In the case of land springs, the water, when it sinks through the surface, is speedily interrupted by a retentive stratum, and there accumulating, soon bursts out in a spring, which ceases to flow a short period after the cause which gave it birth has ceased to operate; but the water which supplies constant springs sinks deeper into the earth, and accumulates in rocky or gravelly strata, which become saturated with the fluid.

LAPIDARY, Art of. The art of the lapidary, or that of cutting, polishing, and engraving gems, was known to the ancients, many of whom have left admirable specimens of their skill. The Greeks were passionate lovers of rings and engraved stones; and the most parsimonious among the higher classes of the Cyrenians are said to have worn rings of the value of ten minæ (about $150 of our money). By far the greatest part of the antique gems that have reached modern times, may be considered as so many models for forming the taste of the student of the fine arts, and for inspiring his mind with correct ideas of what is truly beautiful. With the cutting of the diamond, however, the ancients were unacquainted, and hence they wore it in its natural state. Even in the middle ages, this art was still unknown; for the four large diamonds which enrich the clasp of the imperial mantle of Charlemagne, as now preserved in Paris, are uncut, octahedral crystals. But the art of working diamonds was probably known in Hindostan and China, in very remote periods. After Louis de Berghen's discovery, in 1476, of polishing two diamonds by their mutual attrition, all the finest diamonds were sent to Holland to be cut and polished by the Dutch artists, who long retained a superiority, now no longer admitted by the lapidaries of London and Paris.

The operation of gem-cutting is abridged by two methods: 1st, by cleavage; 2d, by cutting off slices with a fine wire, coated with diamond powder, and fixed in the stock of a hand-saw. Diamond is the only precious stone which is cut and polished with diamond powder, soaked with olive oil, upon a mill plate of very soft steel.

Oriental rubies, sapphires, and topazes, are cut with diamond powder soaked with olive oil, on a copper wheel. The facets thus formed are afterwards polished on another copper wheel with tripoli, tempered with water.

Emeralds, hyacinths, amethysts, garnets, agates, and other softer stones, are cut at a lead wheel, with emery and water; and are polished on a tin wheel with tripoli and water, or, still better, on a zinc wheel, with putty of tin and water.

The more tender precious stones, and even the pastes, are cut on a mill-wheel of hard wood, with emery and water; and are polished with tripoli and water on another wheel of hard wood.

Since the lapidary employs always the same tools, whatever be the stone which he cuts or polishes, and since the wheel discs alone vary, as also the substance he uses with them, we shall describe, very briefly, his apparatus, and the manipulations for diamond-cutting, which are applicable to every species of stone.

Diamonds are cut at the present day in only two modes; into a rose diamond, and a brilliant. We shall therefore confine our attention to these two forms.

The rose diamond is flat beneath, like all weak stones, while the upper face rises into a dome, and is cut into facets. Most usually six facets are put on the central region, which are in the form of triangles, and unite at their summits; their bases abut upon another range of triangles, which being set in an inverse position to the preceding, present their bases to them, while their summits terminate at the sharp margin of the stone. The latter triangles leave spaces between them which are likewise cut each into two facets. By this distribution the rose diamond is cut into 24 facets; the surface of the diamond being divided into two portions, of which the upper is called the crown, and that forming the contour, beneath the former, is called *dentelle* (lace) by the French artists.

According to Mr. Jeffries, in his Treatise on Diamonds, the regular rose diamond is formed by inscribing a regular octagon in the centre of the table side of the stone, and bordering it by eight right-angled triangles, the bases of which correspond with the sides of the octagon; beyond these is a chain of eight trapeziums, and another of sixteen triangles. The collet side also consists of a minute central octagon, from every angle of which proceeds a ray to the edge of the girdle, forming the whole surface into eight trapeziums, each of which is again subdivided by a salient angle (whose apex touches the girdle) into one irregular pentagon and two triangles.

To fashion a rough diamond into a brilliant, the first step is to modify the faces of the original octahedron, so that the plane formed by the junction of the two pyramids shall be an exact square, and the axis of the crystal precisely twice the length of one of the sides of the square. The octahedron being thus rectified, a section is to be made parallel to the common base or *girdle*, so as to cut off 5-18ths of the whole height from the upper pyramid, and 1-18th from the lower one. The superior and larger plane thus produced is called the *table*, and the inferior and smaller one is called the *collet;* in this state it is termed a *complete square table diamond.* To convert it into a brilliant, two triangular facets are placed on each side of the table, thus changing it from a square to an octagon; a lozenge-shaped facet is also placed at each of the four corners of the table, and another lozenge extending lengthwise along the whole of each side of the original square of the table, which with two triangular facets set on the base of each lozenge, completes the whole number of facets on the table side of the diamond, viz., 8 lozenges and 24 triangles. On the collet side are formed 4 irregular pentagons, alternating with as many irregular lozenges radiating from the collet as a centre, and bordered by 16 triangular facets adjoining the girdle. The brilliant being thus completed, is set with the table side uppermost, and the collet side implanted in the cavity made to receive the diamond. The brilliant is always three times as thick as the rose diamond. In France, the thickness of the brilliant is set off into two unequal portions; one-third is reserved for the upper part or table of the diamond, and the remaining two-thirds for the lower part or collet (*culasse*). The table has eight planes, and its circumference is cut into facets, of which some are triangles, and others lozenges. The collet is also cut into facets called *pavillons*. It is of consequence that the pavillons lie in the same order as the upper facets, and that they correspond to each other, so that the symmetry be perfect, for otherwise the play of the light would be false.

Although the rose diamond projects bright beams of light in more extensive proportion often than the brilliant, yet the latter shows an incomparably greater play, from the difference of its cutting.

In executing this, there are formed 32 faces of different figures, and inclined at different angles all round the table, on the upper side of the stone. On the *collet* (culasse) 24 other faces are made round a small table, which converts the culasse into a truncated pyramid. These 24 facets, like the 32 above, are differently inclined and present different figures. It is essential that the faces of the top and the bottom correspond together in sufficiently exact proportions to multiply the reflections and refractions, so as to produce the colors of the prismatic spectrum.

The other precious stones, as well as their artificial imitations, called *pastes*, are cut in the same fashion as the brilliant; the only difference consists in the matter constituting the wheel plates, and the grinding and polishing powders, as already stated.

In cutting the stones, they are mounted on the cement-rod, whose stem is set upright in a socket placed in the middle of a sole piece, which receives the stem of the cement-rod. The head of the rod fills the cup of the sole piece. A melted alloy of tin and lead is poured into the head of the cement-rod, into the middle of which the stone is immediately plunged; and whenever the solder has become solid, a portion of it is pared off from the top of the diamond, to give it a pyramidal form.

There is an instrument employed by the steel polishers for pieces of clockwork, and by the manufacturers of watch-glasses for polishing their edges. It consists of a solid oaken table, the top of which is perforated with two holes, one for passing through the pulley and the arbor of a wheel-plate, made either of lead or of hard wood, according to circumstances; and the other for receiving the upper part of the arbor of the large pulley. The upper pulley of the wheel-plate is supported by an iron prop, fixed to the table by two wooden screws. The inferior pivots of the two pieces are supported by screw-sockets, working in an iron screw-nut sunk into a summer-bar. The legs of the table are made longer or shorter, according as the workman chooses to stand or sit at his employment. Emery with oil is used for grinding down, and tin-[illegible] or colcothar for polishing. The workman lays the piece on the flat of the [illegible] plate with one hand, and [illegible] with a lump of [illegible] round the handle [illegible]

The *Sapphire*, *Ruby*, *Or* *thyst*, *Oriental Emerald*, and *paz*, are gems next in value an to diamond; and they all nearly pure alumina or clay, nute portion of iron as the colo ter. The following analyses affinity in composition of the cious bodies with others in lim estimation.

	[illegible]	[illegible]
Alumina or clay…	[illegible]	[illegible]
Silica…………	[illegible]	[illegible]
Oxide of iron……	[illegible]	[illegible]
Lime…………	[illegible]	[illegible]
	[illegible]	[illegible]

Salamstone is a variety [illegible] of small transparent [illegible] six-sided prisms, of [illegible] bluish colors. The cor[illegible] gammana is frequently found [illegible] six-sided prisms: it is [illegible] brown color, whence it is [illegible] natives *curundu gallé*, cin[illegible] The hair-brown and reddish-brown [illegible] tals are called adamantine spar. [illegible] phire and salamstone are chiefly [illegible] with in secondary repositories, as [illegible] sand of rivers, &c., accompanied by [illegible] tals and grains of octahedral ir[illegible] and of several species of gems. C[illegible] dum is found in imbedded crystals in rock, consisting of idianite. Adam tine spar occurs in a sort of granite.

The finest varieties of sapphire from Pegu, where they occur in the pelan mountains near Syria. Some been found also at Hohenstein in Sax Bilin in Bohemia, Puy in France, an several other countries. The red riety, the ruby, is most highly va Its color is between a bright scarlet crimson. A perfect ruby above [illegible] rats is more valuable than a diamond the same weight. If it weigh [illegible] is worth $[illegible]; 2 carats, $[illegible]; 3 [illegible]; 6 carats, $[illegible]. A very [illegible] ruby, exceeding [illegible] generally [illegible] [illegible] Great Mogul [illegible] stitutes now a jewel in the imperial crown of Russia.

A good blue sapphire of 10 carats is valued at $260. If it weighs 20 carats, its value is $1040; but under 10 carats, the price may be estimated by multiplying the square of its weight in carats into a quarter eagle; thus, one of four carats would be worth $4^2 \times \frac{1}{4}\ \text{E.} = \$40$. It has been said that the blue sapphire is superior in hardness to the red, but this is probably a mistake arising from confounding the corundum ruby with the spinelle ruby. A sapphire of a barbel blue color, weighing 6 carats, was disposed of in Paris by public sale for $350; and another of an indigo blue, weighing 6 carats and 3 grains, brought $300: both of which sums much exceed what the preceding rule assigns, from which we may perceive how far fancy may go in such matters. The sapphire of Brazil is merely a blue tourmaline, as its specific gravity and inferior hardness show. White sapphires are sometimes so pure that when properly cut and polished they have been passed for diamonds.

The yellow and green sapphires are much prized under the names of Oriental topaz and emerald. The specimens which exhibit all these colors associated in one stone are highly valued, as they prove the mineralogical identity of these varieties.

Besides these shades of color, sapphires often emit a beautiful play of colors, or *chatoiement*, when held in different positions relative to the eye or incident light; and some likewise present star-like radiations, whence they are called star-stones or *asterias*; sending forth 6 or even 12 rays, that change their place with the position of the stone. This property, so remarkable in certain blue sapphires, is not, however, peculiar to these gems. It seems to belong to transparent minerals which have a rhomboid for their nucleus, and arises from the combination of certain circumstances in their cutting and structure. Lapidaries often expose the light-blue variety of sapphire to the action of fire, in order to render it white and more brilliant; but with regard to those found at Expailly, in France, fire deepens their color.

3. *Chrysoberyl*, called by Haüy, Cymophane, and by others, Prismatic corundum, ranks next in hardness to sapphire, being 8·5 on the same scale of estimation. Its specific gravity is 3·754. It usually occurs in rounded pieces about the size of a pea, but it is also found crystallized in many forms, of which 8-sided prisms with 8-sided summits are perhaps the most frequent. Lustre vitreous, color asparagus green, passing into greenish-white and olive-green. It shows a bluish opalescence, a light undulating, as it were, in the stone, when viewed in certain directions; which property constitues its chief attraction to the jeweller. When polished, it has been sometimes mistaken for a yellow diamond; and from its hardness and lustre is considerably valued. Good specimens of it are very rare. It has been found only in the alluvial deposites of rivers, along with other species of gems. Thus it occurs in Brazil, along with diamonds and prismatic topaz; also in Ceylon. Its constituents are alumina, 68·66; glucina, 16·00; silica, 6·00; protoxide of iron, 4·7; oxyde of titanium, 2·66; moisture, 0·66; according to Seybert's analysis of a specimen from Brazil. It is difficultly but perfectly fusible before the blow-pipe, with borax and salt of phosphorus. In composition it differs entirely from sapphire, or the rhombohedral corundum.

4. *Spinelle Ruby*, called Dodecahedral corundum, by some mineralogists, and Balas ruby, by lapidaries. Its hardness is 8. Specific gravity, 3·523. Its fundamental form is the hexahedron, but it occurs crystallized in many secondary forms: octahedrons, tetrahedrons, and rhombohedrons. Fracture, conchoidal; lustre, vitreous; color, red, passing into blue and green, yellow, brown, and black; and sometimes it is nearly white. Red spinelle consists of alumina, 74·5; silica, 15·5; magnesia, 8·25; oxide of iron, 1·5; lime, 0·75. Vauquelin discovered 6·18 *per cent.* of chromic acid in the red spinelle. The red varieties exposed to heat become black and opaque; on cooling, they appear first green, then almost colorless, but at last resume their red color. *Pleonaste* is a variety which yields a deep green globule with borax.

Crystals of spinelle from Ceylon have been observed imbedded in limestone, mixed with mica, or in rocks containing adularia, which seem to have belonged to a primitive district. Other varities like the pleonaste occur in the drusy cavities of rocks ejected by Vesuvius. Crystals of it are often found in diluvial and alluvial sand and gravel, along with true sapphires, pyramidal zircon, and other gems; as also with octahedral iron ore, in Ceylon. Blue and pearl-gray varieties occur in Südermannland, in Sweden, imbedded in granular limestone. Pleonaste is met with also in the diluvial sands of Ceylon. Clear and finely colored specimens of spinelle are highly prized as ornamental stones. When the weight of a good spinelle exceeds 4 carats, it is said to be valued at half the price of a diamond of the same weight. M. Brard has seen one at Paris which weighed 215 grains.

5. *Zircon* or *Hyacinth.* Its fundamental form is an isosceles 4-sided pyramid; and the secondary forms have all a pyramidal character. Fracture, conchoidal, uneven; lustre, more or less perfectly adamantine; colors, red, brown, yellow, gray, green, white; which, with the exception of some red tints, are not bright. Hardness, 7·5. Specific gravity, 4·5. Zircon and hyacinth consist, according to Klaproth, of almost exactly the same constituents; namely, zirconia, 70, silica, 25; oxyde of iron, 5. In the white zirconia there is less iron and more silica. Before the blowpipe the hyacinth loses its color, but does not melt. The brighter zircons are often worked up into a *brilliant* form, for ornamenting watch cases. As a gem, hyacinth has no high value. It has been often confounded with other stones, but its very great specific gravity makes it to be readily recognized.

6. *Topaz.* The fundamental form is a scalene 4-sided pyramid; but the secondary forms have a prismatic character; and are frequently observed in oblique 4-sided prisms, acuminated by 4 planes. The lateral planes of the prism are longitudinally striated. Fracture, conchoidal, uneven; lustre, vitreous; colors, white, yellow, green, blue; generally of pale shades. Hardness, 8; specific gravity, 3·5. Prismatic topaz consists, according to Berzelius, of alumina, 57·45; silica, 34·24; fluoric acid, 7·75. In a strong heat the faces of crystallization, but not those of cleavage, are covered with small blisters, which however immediately crack. With borax, it melts slowly into a transparent glass. Its powder colors the tincture of violets green. Those crystals which possess different faces of crystallization on opposite ends, acquire the opposite electricities on being heated. By friction, it acquires positive electricity.

Most perfect crystals of topaz have been found in Siberia, of green, blue, and white colors, along with beryl, in the Uralian and Altai mountains, as also in Kamschatka; in Brazil, where they generally occur in loose crystals, and pebble forms of bright yellow colors; and in Mucla, in Asia Minor, in pale straw-yellow regular crystals. They are also met with in the granitic detritus of Cairngorm, in Aberdeenshire. The blue varieties are absurdly called *oriental aquamarine*, by lapidaries. If exposed to heat, the Saxon topaz loses its color and becomes white; the deep yellow Brazilian varieties assume a pale pink hue; and are then sometimes mistaken for spinelle, to which, however, they are somewhat inferior in hardness. Topaz is also distinguishable by its double refractive property. Tavernier mentions a topaz, in the possession of the Great Mogul, which weighed 157 carats, and cost £27,000 sterling. There is a specimen in the museum of natural history at Paris which weighs 4 ounces 2 grs.

Topazes are not scarce enough to be much valued by the lapidary.

7. *Emerald* and *Beryl* are described in their alphabetical places. Emerald loses its lustre by candle-light; but as it appears to most advantage when in the company of diamonds, it is frequently surrounded with brilliants, and occasionally with pearls. Beryl is the aquamarine of the jewellers, and has very little estimation among lapidaries.

8. *Garnet.* See this stone in its alphabetical place.

9. *Chrysolite*, called *Peridot*, by Haüy; probably the topaz of the ancients, as our topaz was their chrysolite. It is the softest of the precious stones, being scratched by quartz and the file. It refracts double.

10. *Quartz*, including, as sub-species, *Amethyst*, *Rock-crystal*, *Rose-quartz*, *Prase*, or *Chrysoprase*, and several varieties of calcedony, as *Cat's-eye*, *Plasma*, *Chrysoprase*, *Onyx*, *Sardonyx*, &c. Lustre, vitreous, inclining sometimes to resinous; colors, very various; fracture, conchoidal; hardness, 7; specific gravity, 2·69.

11. *Opal*, or uncleavable quartz. Fracture, conchoidal; lustre, vitreous or resinous; colors, white, yellow, red, brown, green, gray. Lively play of light; hardness, 5·5 to 6·5; specific gravity, 2·091. It occurs in small kidney-shaped and stalactitic shapes, and large tuberose concretions. The phenomena of the play of colors in precious opal has not been satisfactorily explained. It seems to be connected with the regular structure of the mineral. Hydrophane, or oculis mundi, is a variety of opal without transparency, but acquiring it when immersed in water, or in any transparent fluid. Precious opal was found by Klaproth to consist of silica, 90; water, 10; which is a very curious combination. Hungary has been long the only locality of precious opal, where it oc-

and they can make 6,000 lbs. of candles per average day throughout the year.

LARD OIL. This year (1851) there are 40 manufacturies of lard oil in Cincinnati, large and small, which consume on an average the year round 1000 packages, of 300 lbs. each, per week, which is equal to 52,000 packages, or 15,600,000 lbs. per annum—from this there is to be deducted one third for stearine, equal to 5,120,000 lbs., leaving for the oil 10,480,000 lbs., which is equal to 1,310,000 gallons, allowing 8 lbs. to the gallon. Only a few years back the manufacture of lard oil was looked on as nothing, now it occupies a very prominent position, and has annually a great influence upon the value of the hog. Lard oil may now be said to have taken the place of all other oils for all purposes at the West. Its manufacture has improved, and will continue until it is quite equal to any other oil. As an application to machinery it is found quite equal to any other oil, on which account, added to its value for lighting purposes, its consumption is increasing in the Southern and Western States. Every town, of any size, when lard can be had, has its factory, as a ready sale is always found for the stearine. Lard, when pressed, yields more oil and less stearine in summer, and less oil and more stearine in winter. The oil is dearer in winter. The manufacture of lard oil is carried on mostly in Cincinnati, the country in every side drawing on it as a centre. Its manufacture is as profitable as any other business of the same capital, its basis being cash. Many of the factories have now temporarily ceased working owing to the present high price of lard, and lard-oil in consequence, has risen from 50 cents up to 90 cents per gallon. (*See* OILS.)

LATH-MAKING MACHINE. Mr. William Merrill, of Northampton, Portage Co., Ohio, has made some excellent improvements on machinery for making laths, for which he has taken measures to secure a patent. The machine makes the laths out of the slabs of logs. It has a circular saw which slits the lath out of a slab as it is fed in, and it has a revolving knife on the saw spindle, which turns the edge of the lath after the saw has cut it. The slab is carried forward the whole length, allowing the saw to cut a lath the whole length, when a projection on the saw frame takes the slab, turns it over on revolving rollers, which bring it back to the person to feed it in, who stands at the end of the frame, and merely feeds in the slabs to the slitting saw. This machine has a register to it, which rings a bell when a hundred laths are finished, to tell the operator that a bunch is ready for binding, so that no counting is required for that purpose.

LAYERS. In gardening, a mode of propagating plants by laying down shoots, and covering a portion of them with soil, so that the extremity of the shoot is left above ground, and the shoot itself not detached from the plant. In order to facilitate the rooting of such layers, the portion of the shoot buried in the soil is fractured by twisting or bruising, or cut with a knife immediately under a bud. This operation, by obstructing the return of the sap from the leaves, occasions its accumulation at the wounded part, when roots are there produced from the effort of nature to perpetuate life.

LAYING. In architecture, the first coat on lath of plasterer's two-coat work, the surface whereof is roughed by sweeping it with a broom; the difference between laying and *rendering* being that the latter is the first coat upon brick.

LEAD. This is one of the metals most anciently known, being mentioned in the books of Moses. It has a gray-blue color, with a bright metallic lustre when newly cut, but it becomes soon tarnished and earthy-looking in the air. Its texture is close, without perceptible cleavage or appearance of structure; the specific gravity of common lead is 11·352; but of the pure metal, from 11·38 to 11·44. It is very malleable and ductile, but soft and destitute of elasticity; fusible at 612° Fahr., by Crighton, at 634° by Kupfer, and crystallizable on cooling, into octahedrons implanted into each other so as to form an assemblage of four-sided pyramids.

There are four oxides of lead. 1. The suboxide, of a grayish-blue color, which forms a kind of crust upon a plate of lead long exposed to the air. It is procured in a perfect state by calcining oxalate of lead in a retort; the dark gray powder which remains, is the pure suboxide. 2. The protoxide is obtained by exposing melted lead to the atmosphere, or, more readily, by expelling the acid from the nitrate of lead by heat in a platinum crucible. It is yellow, and was at one time prepared as a pigment by calcining lead, but is now superseded by the chromate of this metal. Litharge is merely this oxide in the form of small spangles, from having undergone fusion; it is more or less contaminated with iron, copper, and sometimes a little silver. It contains likewise some carbonic acid. The above oxide consists of 104 of metal, and 8 of oxygen—its prime equivalent being 112, upon the hydrogen scale; and it is the base of all the salts of lead. 3. The plumbeous suroxide of Berzelius, the sesquioxide of some British chemists, is the well-known pigment called RED LEAD or *minium*. It consists of 100 parts of metal and 10 of oxygen. 4. The plumbic suroxide of Berzelius, or the peroxide of the British chemists, is obtained by putting red lead in chlorine water, or in dilute nitric acid. It is of a dark brown, almost black color, which gives out oxygen when heated, and becomes yellow oxide. It kindles sulphur when triturated with it. This oxide is used by the analytical chemist to separate, by condensation, the sulphurous acid existing in a gaseous mixture.

Among the ores of lead some have a metallic aspect; are black in substance, as well as when pulverized; others have a stony appearance, and are variously colored, with usually a vitreous or greasy lustre. The specific gravity of the latter ores is always less than 5. The whole of them, excepting the chloride, become more or less speedily black, with sulphureted hydrogen or with hydrosulphurets; and are easily reduced to the metallic state upon charcoal, with a flux of carbonate of soda, after they have been properly roasted. They diffuse a whitish or yellowish powder over the charcoal, which, according to the manner in which the flame of the blowpipe is directed upon it, becomes yellow or red; thus indicating the two characteristic colors of the oxides of lead.

The lead ores most interesting to the arts are:—

1. *Galena*, sulphuret of lead (*See* GALENA.) This ore has the metallic lustre of lead with a crystalline structure derivable from the cube. When heated cautiously at the blowpipe it is decomposed, the sulphur flies off, and the lead is left alone in fusion; but if the heat be continued, the colored surface of the charcoal indicates the conversion of the lead into its oxides. Galena is a compound of lead and sulphur, in equivalent proportions, and therefore consists, in 100 parts, of 86⅔ of metal, and 13⅓ of sulphur, with which numbers the analysis of the galena of Clausthal by Westrumb exactly agrees. Its specific gravity, when pure, is 7·56. Its color is blackish gray, without any shade of red, and its powder is black, characters which distinguish it from *blende* or sulphuret of zinc. Its structure in mass is lamellar, passing sometimes into the fibrous or granular, and even compact. It is brittle. The *specular* galena, so called from its brightly polished aspect, is remarkable for forming the *slickensides* of Derbyshire—thin seams, which explode with a loud noise when accidentally scratched in the mine.

The argentiferous galena has in general all the external characters of pure galena. The proportions of silver vary from one-fifth part of the whole, as at Tarnowitz, in Silesia, to three parts in ten thousand, as in the ore called by the German miners Weisgultigerz; but it must be observed, that whenever this lead ore contains above 5 per cent. of silver, several other metals are associated with it. The mean proportion of silver in galena, or that which makes it be considered practically as an argentiferous ore, because the silver may be profitably extracted, is about two parts in the thousand. (*See* SILVER.) The above rich silver ores were first observed in the Freyberg mines, called Himmelsfurst and Beschertgluck, combined with sulphuret of antimony; but they have been noticed since in the Hartz, in Mexico, and several other places. It is the most abundant lead ore in the United States, occupying an immense tract of country on the Missouri River.

The antimonial galena (*Bournonite*) exhales at the blowpipe the odor peculiar to antimony, and coats the charcoal with a powder partly white and partly red. It usually contains some arsenic.

2. The *Seleniuret of lead* resembles galena, but its tint is bluer. At the blowpipe it exhales a very perceptible smell of putrid radishes. Nitric acid liberates the selenium. When heated in a tube, oxide of selenium of a carmine red rises along with selenic acid, white and deliquescent. The specific gravity of this ore varies from 6·8 to 7·69.

3. *Native minium* or *red lead* has an earthy aspect, of a lively and nearly pure red color, but sometimes inclining to orange. It occurs pulverulent, and also compact, with a fracture somewhat lamellar. When heated at the blowpipe upon charcoal, it is readily reduced to metallic lead. Its specific gravity varies from 4·6 to 8·9. This ore is rare.

4. *White lead, carbonate of lead.*—This ore, in its purest state, is colorless and transparent like glass, with an adamantine lustre. It may be recognized by the following characters:—

Its specific gravity is from 6 to 6·7;

it dissolves with more or less ease, and with effervescence, in nitric acid; becomes immediately black by the action of sulphureted hydrogen, and melts on charcoal before the blowpipe into a button of lead. According to Klaproth, the carbonate of Leadhills contains 82 parts of oxide of lead, and 16 of carbonic acid, in 98 parts. This mineral is tender, scarcely scratches calc-spar, and breaks easily with a waved conchoidal fracture. It possesses the double refracting property in a very high degree; the double image being very visible on looking through the flat faces of the prismatic crystals. Its crystalline forms are very numerous, and are referrible to the octahedron, and the pyramidal prism. This ore has been found very sparingly in the United States.

5. *Vitreous lead*, or *sulphate of lead*.—This mineral closely resembles carbonate of lead; so that the external characters are inadequate to distinguish the two. But the following are sufficient. When pure, it has the same transparency and lustre. It does not effervesce with nitric acid; it is but feebly blackened by sulphureted hydrogen; it first decrepitates and then melts before the blowpipe into a transparent glass, which becomes milky as it cools. By the combined action of heat and charcoal, it passes first into a red pulverulent oxide, and then into metallic lead. It consists, according to Klaproth, of 71 oxide of lead, 25 sulphuric acid, 2 water, and 1 iron. That specimen was from Anglesea; the Wanlockhead mineral is free from iron. The prevailing form of crystallization is the rectangular octahedron, whose angles and edges are variously modified. The sulphato-carbonate, and sulphato-tricarbonate of lead, now called *Leadhillite*, are rare minerals which belong to this head.

6. *Phosphate of lead*.—This, like all the combinations of lead with an acid, exhibits no metallic lustre, but a variety of colors. Before the blowpipe upon charcoal, it melts into a globule externally crystalline, which, by a continuance of the heat, with the addition of iron and boracic acid, affords metallic lead. Its constituents are 80 oxide of lead, 18 phosphoric acid, and 1·6 muriatic acid, according to Klaproth's analysis of the mineral from Wanlockhead. The constant presence of muriatic acid in the various specimens examined is a remarkable circumstance. The crystalline forms are derived from an obtuse rhomboid. Phosphate of lead is a little harder than white lead; it is easily scratched, and its powder is always gray. Its specific gravity is 6·9. It has a vitreous lustre, somewhat adamantine. Its lamellar texture is not very distinct; its fracture is wavy, and it is easily frangible. The phosphoric and arsenic acids being, according to M. Mitscherlich, isomorphous bodies, may replace each other in chemical combinations in every proportion, so that the phosphate of lead may include any proportion, from the smallest fraction of arsenic acid to the smallest fraction of phosphoric acid, thus graduating indefinitely into arseniate of lead. The yellowish variety indicates, for the most part, the presence of arsenic acid. This ore occurs at the lead mine near Freyburg, in Maine. It is also found in Tennessee.

7. *Muriate of lead. Horn-lead*, or *murio-carbonate*.—This ore has a pale yellow color, is reducible to metallic lead by the agency of soda, and is not altered by the hydrosulphurets. At the blowpipe it melts first into a pale yellow transparent globule, with salt of phosphorus and oxide of copper; and it manifests the presence of muriatic acid by a bluish flame. It is fragile, tender, softer than carbonate of lead, and is sometimes almost colorless, with an adamantine lustre. Spec. grav., 606. Its constituents, according to Berzelius, are lead, 25·84; oxide of lead, 57·07; carbonate of lead, 6·25; chlorine, 8·84. silica, 1·46; water, 0·54; in 100 parts. The carbonate is an accidental ingredient, not being in equivalent proportion. Klaproth found chlorine, 13·67; lead, 39·98; oxide of lead, 22·57; carbonate of lead, 23·78.

8. *Arseniate of lead*.—Its color of a pretty pure yellow, bordering slightly on the greenish, and its property of exhaling by the joint action of fire and charcoal a very distinct arsenical odor, are the only characters which distinguish this ore from the phosphate of lead. The form of the arseniate of lead, when it is crystallized, is a prism with six faces, of the same dimensions as that of phosphate of lead. When pure, it is reducible upon charcoal, before the blowpipe, into metallic lead, with the copious exhalation of arsenical fumes. Its spec. grav. is 5·05. It consists of oxide of lead, 77·5; arsenic acid, 12·5; phosphoric acid, 7·5; hydrochloric acid, 1·5.

9. *Molybate of lead*, or *yellow lead*, is found at Southampton, Mass. It occurs in obtuse octohedrons and tabular crystals. Spec. grav. 5·05. It consists of

58·4 oxide of lead, 38 molybdic acid, and 2·08 oxide of iron.

The foregoing are the most common ores of lead, all of which, except the chromate and molybdate, are used to procure metallic lead. It is, however, from the sulphuret (galena) that the great bulk of the lead of commerce is obtained. Under the article *Metallurgy* the treatment of lead ores is noticed, and it may therefore be here merely stated that the chief object to attain, after having procured a clean ore, is to get rid of the sulphur—which may be accomplished either by roasting in the open air or in reverberating furnaces. In this way the sulphur is volatilized, and the lead, either as oxide or reduced to the state of metal, runs into the basin or crucible of the furnace when it is deoxidized by being kept in contact with ignited charcoal. In Germany and France another mode is adopted, which consists in throwing into the reverberating furnace 28 per cent. of old iron. In a short time the sulphur leaves the lead and passes over to the iron, and the lead is in the state of pure metal in the bottom of the furnace. This plan saves time and labor, but the iron is lost. Its value, however, is trifling.

The uses of lead and its oxides are very numerous: the latter as paints, chiefly, and the former in roofing, and as gutters, cisterns, and pipes. For these this metal has many advantages; it is soft and malleable, so that two edges may be folded over and hammered water-tight without soldering; this prevents rupture from expansion, which often occurs in soldered vessels. As a means of carrying water it is in constant use, though liable to many objections. The metal, when pure, is perfectly insoluble in water, but the oxide and carbonate of lead are soluble in water containing an excess of carbonic acid. When water runs through a lead pipe it oxidizes it in a very short time, forming a white or yellow crust on the inside. This dissolves to a small extent in the water, and this latter, when drank, produces all the symptoms of poisoning by lead. On this account, lead pipes have been superseded by iron, zinc, gutta percha, and glass pipes. Dr. Christison has shown, that the purer the water, that is the more pure it is from saline matters, the greater is the corrosion of the pipe and the amount of lead dissolved: but that if the water contain much saline matter, especially sulphates, the lead is precipitated out of the water and no injury can arise. He recommended that new leaden pipes should be plugged up for a few days with a solution of sulphate of soda or phosphate of soda until the whole inside of the pipe was coated with a crust of sulphate or phosphate of lead, which effectually protects the pipe from any further action. If this cannot be conveniently done, a zinc cistern may be used to receive the water which has flowed through the pipe: after having lain a few hours, the lead present in the water will be thrown down as a dark powder on the surface of the zinc. Should this plan not be adopted, the water should be allowed to run freely through the pipes for two days before it be applied to any domestic purpose. Vessels of lead should never be used for culinary or dairy purposes. Lead is used for making *shot* and *solder*. It forms an imperfect alloy with copper. The common *brass cocks* is an alloy of these two metals. The union is, however, so partial, that on heating the cock the lead melts out and leaves the copper. This process is called liquation. The *nitrate of lead* is made by heating the metal with warm nitric acid,—a crude and weak solution of this salt of lead, constituted the *disinfecting liquid* of Ledoyen & Calvert, which has been so preposterously overrated. It is capable of decomposing animal sulphurets, phosphurets, and hence of removing the unpleasant smells of drains and water-closets, but beyond this action it has hardly any, and it is quite incapable of breaking up and rendering innocuous a *miasm* in the way in which chlorine does. Calvert fell a victim to his trials of this solution in the Fever Hospitals in Canada.

Lead constituted the writing-table of the ancient Greeks and Romans.

When metallic lead is strongly heated in the reverberatory furnace it beomes of a dull color on the surface, loses its metallic appearance, and puts on the appearance of a dross or powder. When this dross is heated to a low ignition, it becomes of a dull yellow color, and is called *common massicot*; and, by a higher heat and longer exposure to the air, it assumes a deeper yellow, and is then called *massicot*. This is the *protoxide of lead*, and consists, in 112 parts, of 104 lead and 8 oxygen. When it contains about four per cent. of carbonic acid, it is called *litharge*. It unites with acids, and is the base of all the salts of lead. If the protoxide, or metallic lead, be subjected, during 48 hours, to the heat of a reverberatory furnace, it passes to the condition of red oxide, or what is commonly called *minium*, or *red lead*. Its composition is, in 116 parts, 104 lead, 12 oxygen.

Lead forms a compound with chlorine. The union is effected by adding muriatic acid, or a solution of common salt, to the acetate or nitrate of lead dissolved in water. This *chloride* fuses at a temperature below redness, and forms, as it cools, a semi-transparent horny mass, sometimes called *horn lead*.

The pigment called *mineral*, or *patent yellow*, is a compound of the chloride and protoxide of lead. It is prepared for the purposes of the arts by the action of moistened sea-salt on litharge, by which means a portion of the protoxide is converted into chloride.

WHITE-LEAD, or carbonate of lead, is prepared by exposing narrow slips, or thin lead, to the steam of vinegar, in a close vessel. The slips are laid on bars of wire above the surface of the boiling vinegar. For flake-white, dilute sulphuric acid is preferred.

There is, (says Thomson,) only one direct poison among the salts of lead, which is the carbonate; and, when the other salts of lead display poisonous effects, these are to be attributed either wholly, or in part, to their conversion into the carbonate. This salt acts as a powerful sedative astringent on the living system, diminishing the nervous energy, and, consequently, greatly depressing the powers of the circulation, and lowering the tone of the muscular system. It is probably taken into the blood, which may account for its slow operation when it is introduced into the stomach in minute doses, for a considerable length of time, and also for its producing similar effects, when applied to the surface of the body denuded of the cuticle, or in a state of ulceration.

Great mischief has been produced by the use of lead in dairies. If the milk runs into the slightest acidity, some lead will be dissolved, and injurious consequences will follow if it is taken into the stomach.

Lead in Wines is detected by a black precipitate, which will be instantly produced by the following mixture:—Expose equal parts of sulphur and powdered oyster-shells to a white heat for a quarter of an hour. When cold, add an equal quantity of cream of tartar, and boil them with water in a strong bottle for an hour. Transfer to ounce phials, and add to each 20 drops of muriatic acid.

To reduce Red Lead. Heat in a Hessian crucible 2 oz. of red lead with 2 drs. of powdered charcoal, and 1 oz. of common salt. The result will be 2 oz. of pure metal.

When nitrate of lead or of bismuth is boiled with carbonate of lime, magnesia, or barytes, these salts are decomposed, and the oxides are so completely precipitated that hydrosulphuret of ammonia shows no traces of them in the solution. Carbonate of lime, when added to a cold solution of these metals, precipitates only the oxide of bismuth. Several methods have been proposed for separating the lead which is contained in the bismuth of commerce; but carbonate of lime is preferable.

LEAD, BLACK. *See* PLUMBAGO.

LEAD, FOR SOUNDING. The common hand lead weighs 11 lbs. with about 20 fathoms of line. The leadsman stands somewhere on the side of the vessel, leaning against a band for the purpose: lets the lead descend near the water; then, swinging it over his head once, or twice, if the ship is going fast, throws it forward. The line is marked at 5, 7, 10, 13, 17, and 20 fathoms. The numbers between are called *deeps*; thus, "by the mark 7," "by the deep nine," indicates 7 and 9 fathoms.

When the depth is great, the deep-sea lead of 28 lbs. is used. The lead is dropped from the fore part of the vessel, the line being passed outside all. It is generally necessary to heave the ship to.

LEAD-SHOT. The origin of most of the imperfections in the manufacture of lead-shot is the too rapid cooling of the spherules by their being dropped too hot into the water, whereby their surfaces form a solid crust, while their interior remains fluid, and, in its subsequent concretion, shrinks, so as to produce the irregularities of the shot.

The patent shot towers obviate this evil, by exposing the fused spherules after they pass through the cullender, to a large body of air during their descent into the water tub placed on the ground. The greatest erection of this kind is probably at Villach, in Carinthia, being 240 Vienna, or 249 English feet high.

The quantity of arsenic added to the mass of melted lead, varies according to the quality of this metal; the harder and less ductile the lead is, the more arsenic must be added. About 3 pounds of either white arsenic or orpiment is enough for one thousand parts of soft lead, and about

8 for the coarser kinds. The latter are employed preferably for shot, as they are cheaper and answer sufficiently well. The arsenical alloy is made either by introducing some of this substance at each melting, or by making a quantity of the compound considerably stronger at once, and adding a certain portion of this to each charge of lead. If the particles of the shot appear lens-shaped, it is a proof that the proportion of arsenic has been too great; but if they are flattened upon one side, if they are hollowed in their middle, called *cupping* by the workman, or drag with a tail behind them, the proportion of arsenic is too small.

The following is the process prescribed by the patentees, Ackerman and Martin. Melt a ton of soft lead, and sprinkle round its sides, in the iron pot, about two shovelfuls full of wood ashes, taking care to leave the centre clear; then put into the middle about 40 pounds of arsenic, to form a rich alloy with the lead. Cover the pot with an iron lid, and lute the joints quickly with loam or mortar, to confine the arsenical vapors, keeping up a moderate fire to maintain the mixture fluid for three or four hours; after which skim carefully, and run the alloy into moulds to form ingots or pigs. The composition thus made is to be put in the proportion of one pig or ingot into 1000 pounds of melted ordinary lead. When the whole is well combined, take a perforated skimmer and let a few drops of it fall from some height into a tub of water. If they do not appear globular, some more arsenical alloy must be added.

Lead which contains a good deal of pewter or tin must be rejected, because it tends to produce elongated drops or tails.

LEATHER. *See* TANNING.

LEATHER (VARNISHED FRENCH, MANUFACTURE OF). This process consists of two operations:—First, the preparation of the skin, described under the head *Tanning;* and, second, the varnishing of the leather thus dressed. In the preparation of the leather, linseed oil, made to dry quick by means of metallic oxides and salt, is employed as the basis. For each twenty-two gallons of linseed oil, twenty-two lbs. of white lead and twenty-two lbs. of litharge are employed, and the oil boiled with those ingredients until it has attained the consistency of syrup. This preparation, mixed either with chalk, or ochres, is applied to leather by means of appropriate tools, and well worked into the pores; three or four layers are applied in succession, taking care to dry each layer thoroughly before the application of the next coating. Four or five coatings of the dried linseed oil, without the admixture of the earthy substances, are then given; the addition of very fine ivory black and some oil of turpentine is usually made to the oil. These coatings are put on very thin, and when carefully dried the leather is rubbed over with fine pumice stone powder to render the surface perfectly smooth and even, for the reception of the varnish. The varnish is composed as follows:—Ten lbs. of oil prepared as above, half a lb. of asphalt or Jewish bitumen, five lbs. of copal varnish, and ten lbs. of turpentine. The oil and asphalt are first boiled together, the copal varnish and turpentine added afterward, and the mixture well stirred. Instead of asphalt, Prusian blue or Ivory black may be employed. This varnish must be kept in a warm place for two or three weeks before it is fit for use. The greatest possible care must be taken both before and during the application of the varnish to prevent the adherence of any dust to the leather. The leather, when varnished, must be put into drying stoves, heated to about 200 degrees or more, according to the nature of the leather and the varnish employed.

LEECH, ARTIFICIAL. Dr. Charles Rodgers, of Jefferson, Wisconsin, has invented a most ingenious little instrument as a substitute for the common cupping process, and as an artificial leech. In the first place the inflamed part of the patient, or on whatever part on which it is designed to operate, is perforated in one or more places by a lancet, impelled in a tube by blowing it like a Guinea arrow with the mouth. The artificial leech consists of a glass tube, which is set upon the wound, and by a small metal tube at the other end, all the air is exhausted, when the blood, &c., rises in the vacuum, and communication is then cut off from the atmosphere by an ingenious slide valve, which stops the mouth of the small metal tube. This invention is a neat improvement in the art of surgery. Measures have been taken to secure a patent. It appears to be similar to the artificial leech of Alexander, in London.

LEGHORN HATS. It is chiefly in the neighborhood of Florence, Pisa, the district of Sienna, and in the upper part of the valley of the Arno, that the best platting is made for straw hats. The straw used in working these hats is grown in districts mountainous and sterile. It is produced from a kind of wheat, of which the grain is very small. This straw, though slender, has much consistence, and the upper part of the stalk being perfectly hollow, is easily dried. It is pulled out of the earth before the grain begins to form. After being freed from the soil, which adheres to the root, it is formed into small sheaves, to be winnowed; the part above the last joint of the stem is then plucked off, which is from four to six inches long, the ear remaining attached to it. This being done, it is bleached by the dew and the sunshine. Rain is very injurious to it, and destroys much of its whiteness. The lower parts of the straw are treated in the same manner, and employed in forming hats of an inferior quality. The upper parts, torn off just to the knot, are sorted according to their degree of fineness. This stapling is made with much care, and usually affords straw of three different prices. A quantity of straw, worth 8 cents, after having undergone this process, is sold for $1·25. The tress is formed of seven or nine straws, which are begun at the lower end, and are consumed, in platting, to within an inch and a half of the upper extremity, including the ear. All the ends of the straws that have been consumed are left out, so that the ears are on the other side of the tress. As fast as it is worked, it is rolled on a cylinder of wood. When it is finished, the projecting ends and ears are cut off; it is then passed with force between the hand and a piece of wood, cut with a sharp edge, to press and polish it. The tresses thus prepared are so used that a complete hat shall be formed of one piece. They are sewed together with raw silk. The diameter of the hat is in general the same; the only difference consists in the degree of fineness, and, consequently, the number of turns which the tress has made in completing the hat: some having from twenty to eighty such turns.

LEMON (CITRUS). One species of the genus, of which orange is another. The outer rind contains a fragrant oil. The juice is a very refreshing modification of citric acid with mucilage, sugar, and water. The trees produce thousands of the fruit. To keep, the juice is crystallized, and, when wanted, dissolved in any liquid. The essential oil is produced by distillation with water and alcohol.

LEMON DROPS. Mix ⅛ lb. of sugar with 8 drs. of salt of sorrel in a little water, boil, add ½ lb. more sugar, and 8 drops of essence of lemon; or, (tartaric acid, and citric acid, for the sorrel-salt, and lemon); then with a crooked wire draw it out in drops on a slab.

LEMONADE POWDERS. Mix, and divide into 24 parts, 6 oz. of sugar, 10 drops of essence of lemon, and 1 oz. of tartaric acid.

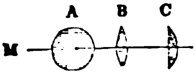
LENS. In Optics, a thin piece of glass or any other transparent substance, bounded on both sides by polished spherical surfaces, or on the one side by a spherical and on the other by a plain surface; and having this property, that parallel rays of light, in passing through it, have their direction changed, so as to converge to a given point, called the *principal focus* of the lens, or to diverge as if they proceeded from that point.

Lenses are, in fact, mere multiplying-glasses, with an infinite number of sides, producing an infinite number of images, whose visual resultant is one blended figure, expanded over the whole visual angle of the glass, in length and in breadth, and therefore said to be magnified. The images produced by the inclined or oblique sides, owing to unequal refractions, are however highly-colored in the focus; and, owing to the unequal inclinations of the spherical form, the rays do not all converge exactly to the same point. Lenses have therefore been very properly composed of two kinds of glass, which refract differently or unequally, and then, by combining a convex and a concave, the inequality is destroyed, and the image free from color. The forms too have been varied from the spherical to the parabolic, with a view to concentrate the rays in one point. Lenses are manufactured with great precision, by steam power, by Jenkins's machine, fixed in concave basins, and the friction proceeds on some hundreds at the same time.

A *spherical lens*, shown at A, is a sphere or globule of glass.

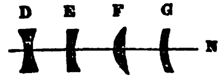
Lenses receive different denominations, according to their different forms.

A *double convex lens*, shown at B, is a solid formed by two convex spherical surfaces; and is *equally convex* or *unequally convex*, according as the radii of its two surfaces are equal or unequal.



A *plano-convex lens*, C, is that of which one of the surfaces is *plane* and the other *convex*.

A *double concave lens*, D, is bounded by two *concave* spherical surfaces, which have either the same or a different curvature.



A *plano-concave lens*, E, has one surface *plane*, and the other *concave*.

A *meniscus*, F (so called from its resemblance to a little moon,) is a lens of which one of the surfaces is *convex* and the other *concave*, and which meet if continued. The radius of the convex surface is consequently smaller than the radius of the concave.

A *concavo-convex lens*, G, is that of which one of the surfaces is *concave* and the other *convex;* but in this case the surfaces will not meet though continued, the radius of the concave surface being smaller than that of the convex one.

The straight line M N which passes through the centres of all the curved surfaces, or is perpendicular to both surfaces of the same lens, is called the *axis* of the lens ; and it is in this line that the focus of the lens is situated.

It was observed, at an early period, that a transparent body of a spherical form has the property of collecting at the focus the parallel rays of light which fall on its surface. But it was remarked, at the same time, that the illumination at these foci was extremely feeble, in consequence of the thickness of the glass which the light had to pass through. This inconvenience is removed by taking only two small segments instead of the entire sphere ; by which means, as the refraction takes place only at the surfaces, and not in the interior of the glass, the very same refraction of the rays is produced as when the whole sphere is used ; and the thickness of the glass being greatly diminished, the rays pass through it in much greater number, and the intensity of the light in the focus is much more considerable.

The rules for finding the focal distances of the different sorts of lenses are the following. They depend in some measure on the refracting power of the glass. We shall here suppose the index of refraction to be 1·500.

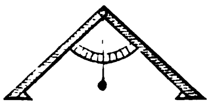
Lenses of great power and correct form are made in this country.

LEVEL. An instrument which shows the direction of a straight line parallel to the plane of the horizon.

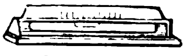
The plane of the sensible horizon is indicated in two ways : by the direction of the plummet or plumb-line, to which it is perpendicular ; and by the surface of a fluid at rest. Accordingly, levels are formed either by means of the plumb-line, or by the agency of a fluid applied in some particular manner. They all depend upon the same principle, namely, the action of terrestrial gravity.

Levels in which the plumb-line forms the essential part are those most usually employed for the common purposes required by bricklayers, masons, carpenters, &c. They are constructed under many different forms, but the general principle is as follows : A frame or board is prepared, having one edge perfectly straight, and a straight line is drawn on the frame at right angles to the straight edge. To some point of this straight line a thread carrying a plummet is attached ; consequently, when the frame is placed in such a position that the thread of the plummet, hanging freely, coincides with the straight line, the straight edge of the frame, which is perpendicular to it, must be horizontal. See PLUMMET.

The *Artillery Foot Level*, and the *Gunner's Level*, besides the line and plummet, have a scale for showing the inclination of a straight line to the horizon. The former has two equal legs or branches placed at right angles ; and from their point of junction a thread and plummet hangs, and plays over a quadrant divided into twice 45° from the middle. The plane or line on which the two ends rest is horizontal when the thread falls over the zero point of the scale ; and when it falls over any other point, the degree marked on the scale indicates the inclination of the line to the horizon. The gunner's level is on the same principle, though differently constructed ; the thread or plummet being replaced by a solid piece of brass, loaded at the lower end, and the legs, or rather the edges, of the brass plate making an angle of 45°. It is used in the same manner as the former.



Spirit Level.—By far the most convenient and also the most accurate level is the spirit level, represented in the annexed figure ; "which is nothing more than a glass tube nearly filled with a liquid (spirit of wine being now generally used, on account of its *mobility*, and not being liable to freeze,) the bubble in which, when the



tube is placed horizontally, would rest indifferently in any part if the tube could be made mathematically straight; but that being impossible to execute, and every tube having some slight curvature, if the convex side be placed upwards the bubble will occupy the higher part, as in the figure (where the curvature is purposely exaggerated.)

The accuracy of the indications of the level depends in a considerable degree on the regularity of the interior surfaces of the tube. They are commonly made of glass tubes in the same state as they are obtained at the glass-house; but when very great accuracy is required, as in astronomical observations, the interior surfaces are sometimes ground so as to give them a regular cylindrical, or rather spindle form, with a slight spherical curvature. The tube and bubble must be of considerable length. The larger the bubble, the more freely it moves, and consequently, the more sensible is the level to a small inclination. With proper care they can be executed, it is said, with such delicacy as to indicate a single second of angular deviation from exact horizontality.

LEVER. In Mechanics, an inflexible rod movable about a *fulcrum* or prop, and having forces applied to two or more points in it. The lever is one of the mechanical powers; and, being the simplest of them all, was the first that was attempted to be explained. Its properties are treated of by Aristotle; but the first accurate explanation was given by Archimedes, in his Treatise *De Equiponderantibus.*

In treating of the lever, it is convenient to distinguish the forces applied to it by different names. One is usually called the *power*, the other the *weight* or *resistance.*

FIG. 1.

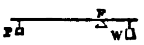
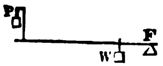


FIG. 2.



Levers are commonly divided into three kinds, according to the relative positions of the power, the weight, and the fulcrum. In a lever of the first kind (fig. 1), the fulcrum F is between the power P and the weight W. In a lever of the second kind, (fig. 2), the weight W is between the fulcrum F and the power P. In a lever of the third kind (fig. 3), the power P is between the fulcrum F and the weight W.

FIG. 3

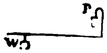
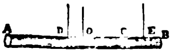


FIG. 4.



The general principle of the lever is, that when the power and weight are in equilibrio, they are to each other inversely as their distances from the fulcrum. This property is almost an obvious consequence from the principle of virtual velocities; but it may be deduced from more familiar considerations. Let A B be a cylinder or bar of homogeneous matter. If supported from the middle O, the two ends would evidently balance each other, and the pressure at O would be the same as if the whole matter of the bar were concentrated in that point. Suppose it to consist of two parts, A C and B C, these again would be separately supported at their middle points D and E; or the whole of the matter in A C may be conceived to be concentrated at D, and the whole of that in B C at E, and the equilibrium would not be disturbed. Hence the weight of A C attached at D, and the weight of B C attached at E, would balance the inflexible line D E, if supported at O, the centre of the whole bar A B. But O D=A O—A D=½ A B—½ A C=½ B C; and O E=O B—E B=½ A B—½ C B =½ A C; consequently, O D is to O E as B C to A C; or O D is to O E as the weight concentrated at E to the weight concentrated at D. This demonstration is commonly ascribed to Archimedes.

This proposition shows the advantage obtained by using the lever as a mechanical engine. The arm P F (fig. 1), is commonly longer than W F, and, consequently, when there is equilibrium the weight exceeds the power. The proportion in which the weight exceeds the power is called the *mechanical advantage*, or purchase. Suppose P F (figs. 1 and 2)=4 feet, and W F=1 foot; then a power of 1 lb. acting at P will overcome a resistance of 4 lbs. at W.

Suppose the lever with the weights P and W to turn round the fulcrum, the two points to which P and W are attached will describe arcs proportional to the radii F P, F W; consequently, the power P is to the weight W as the velocity of the weight to the velocity of the power. Therefore in this, as in all mechanical engines, when a small power raises a great weight, the velocity of the power is much greater than the velocity of the weight; and what is gained in force is therefore said to be lost in time.

When the power and the weight do not act on the lever in directions perpendicular to its length, or when the arms of the lever are not in the same straight line, or are bent, then the power and the weight are not to each other reciprocally as the arms of the lever, but as the straight lines drawn from the fulcrum perpendicular to the respective directions in which the power and the weight take effect.

LICHENS; a family of plants, belonging to the class *cryptogamia*, containing about 1400 known species, are under several genera. Their substance is powdery, crustaceous, membranous, coriaceous, or even corneous. They are common every where, adhering to rocks, the trunks of trees, and barren soil. On ascending mountains, they are found flourishing beyond the limit of all other plants, even to the verge of perpetual snow. Many of them, fixing upon the hardest rocks, by retaining moisture, facilitate their decomposition and promote the formation of soil. Several of the species are used for sustenance in times of scarcity, by the inhabitants of the northern regions.

Iceland moss is exceedingly abundant in the arctic regions, and often affords aliment to the inhabitants, either in the form of gruel or bread, which last is very nutritious. The taste is bitter, astringent, and extremely mucilaginous. It is frequently employed in pharmacy, in the composition of various pectoral lozenges and syrups, and is celebrated as an article of diet, in combination with milk, in coughs and pulmonary affections.

Orchil (*rocella tinctoria*) is also an important article, though less used now than formerly, on account of the fugitiveness of the rich purple and rose-colored dyes which it yields. Some of its tints, however, are capable of being fixed, and it is, besides, employed for staining marble, forming blue veins and spots. Several other lichens afford dyes of various colors, as litmus.

Lichen, Liverwort, or Algæ, are the stunted herbage of the arctic circle, and of barren heaths. In Iceland and Lapland, it is eaten in broth and milk, and even made into bread, its bitterness being removed by washing in hot waters. It contains much mucilage or gluten, and has been extensively used in pulmonary complaints, and as a demulcent, relieving cough, and correcting all acrid secretions.

Lichen, Orchil, or Argol, alluded to above, is famous for its dye of purple, blue, violet, &c. It is mostly brought from the Canary Isles, and is there ground in a mill, mixed with pearl-ash and urine, and sold in cakes. It is used to heighten colors, but is very evanescent, except when used with a tin solution, which gives to it a permanent red dye.

LICK, or SALTLICK. A salt spring is called a lick in the Western States, from the circumstance that the earth about it, which is impregnated with saline particles, is licked by the bison and the deer. Many of these licks appear to have existed before the habitation of the earth by man, as the bones of the mastodon and other fossil animals are found abundantly in them. They appear to be situated in the upper secondary beds, and contain both iodine and bromine in combination dissolved in the water. The latter substance is in such marked quantity as to make these springs the source of the bromine manufacture.

LIFE-BOAT. A boat originally made at Shields, in 1789, by Mr. Greathead, for saving the crews of shipwrecked vessels. The following are the general principles: The boat is wide and shallow; the head and stern are alike, for pulling in either direction, and raised, to meet the waves; it pulls double-banked, the oars being fir, for lightness, and fitted with thole pins and grummets, and is steered with an oar. The boat is cased round inside, on the upper part, with cork, in order to secure her buoyancy with as many persons as she can carry, even though full of water; the cork likewise assists in maintaining, or, if overset, in recovering, the position of stable equilibrium. The boat is painted white, to be conspicuous in emerging from the hollow of the sea. It is a curious fact that the smugglers paint their boats white for the contrary reason, because dark-colored objects alone are discernible in dark nights.

If a spheroid be divided into quarters, each quarter is elliptical, and resembles the half of a wooden bowl, having a *curvature with projecting ends*. Such a vessel thrown into the sea cannot be upset, or lie with the bottom upwards, owing to the ends. The length is 30 feet, the breadth 10 feet; the depth from the top of the gunwale to the lower part of the keel in midships, 3 feet 3 inches; from the gunwale to the platform (within), 2 feet 4 inches; from the top of the stems (both ends being similar) to the horizontal line of the bottom of the keel, 5 feet 9 inches. The keel is a plank of 3 inches thick, of a proportionate breadth in midships, narrowing gradually towards the ends, to the breadth of the stems at the bottom, and forming a great convexity downwards. The stems are segments of a circle, with a considerable rake. The bottom section, to the floor-heads, is a curve fore and aft, with the sweep of the keel. The floor-timber has a small rise, curving from the keel to the floor-heads. A bilge-plank is wrought-in on each side, next the floor-heads, with a double-rabbet groove, of a similar thickness with the keel; and, on the outside of this, are fixed two bilge-trees, corresponding nearly with the level of the keel. The ends of the bottom section form that fine kind of entrance observable in the lower part of the bow of the fishing-boat, called a cobble, much used in the north. From this part to the top of the stem it is more elliptical, forming a considerable projection. The sides, from the floor-heads to the top of the gunwale, flaunch off on each side in proportion to above half the breadth of the floor. The breadth is continued far forwards towards the ends, leaving a sufficient length of straight side at the top. The sheer is regular along the straight side, and more elevated towards the ends. The gunwale fixed to the outside is three inches thick.

The sides, from the under part of the gunwale, along the whole length of the regular sheer, extending 21 feet 6 inches, are cased with layers of cork, to the depth of 16 inches downwards; and the thickness of this casing of cork being 4 inches, it projects at the top a little without the gunwale. The cork, on the outside, is secured with thin plates or slips of copper, and the boat is fastened with copper nails. The thwarts, or seats, are five in number, double-banked; consequently, the boat may be rowed with 10 oars. The thwarts are firmly stanchioned. The side-oars are short, with iron tholes and rope grummets, so that the rower can pull either way. The boat is steered with an oar at each end; and the steering-oar is one-third longer than the rowing-oar. The platform placed at the bottom, within the boat, is horizontal, the length of the midships, and elevated at the ends, for the convenience of the steersman, to give him a greater power with the oar. The internal part of the boat next the sides, from the under part of the thwarts down to the platform, is cased with cork; the whole quantity of which, affixed to the life-boat, is nearly seven cwt. The cork contributes much to the buoyancy of the boat, and is a good defence in going alongside a vessel, and is of use in keeping the boat in an erect position in the sea, or rather for giving a very lively and quick disposition to recover from any sudden cant or lurch, which she may receive from the stroke of a heavy wave.

The boats, in general, of this description, are painted white on the outside: this color being more conspicuous when rising from a hollow of the sea. The bottom of the boat is varnished. The oars are made of fir, of the best quality. In the management, she requires twelve men to work her, that is, five on each side, rowing double-banked, with an oar slung over an iron thole, with a grummet, so as to enable the rower to pull either way, and one man at each end to steer her, and to be ready at the opposite end to take the steer-oar, when wanted. The best method, if the direction will admit of it, is to head the sea. The steersman should keep his eye fixed upon the wave or breaker, and encourage the rowers not to give way, as the boat rises to it; being then aided by the force of the oars, she launches over it with vast rapidity, without shipping any water. When a wreck is reached, if the wind blows to the land, the boat will come in shore, without any other effort than steering.

Scheerboom & Co. have recently invented an apparatus for converting any boat or vessel into a life-boat, in cases of danger, and it is recommended by high authorities.

Mr. Holbrook, of Hull, England, constructed a life-boat, the hull of which is broad, and the framework composed of wrought iron covered with net. The body is divided into six compartments, containing bundles of floaters, perfectly air-tight, and separate from each other so that injury to one will not affect the rest. The peculiarity of the boat is, it has no bottom except a slight framework of cordage or netting, the object of the arrangement being to allow the water to rise within the boat to the level of that without, and so secure a permanent ballast of water which precludes the possibility of being capsized in a heavy sea. Thus the countervailing properties of buoyancy and steadiness are perfectly secured. The internal arrangements include means for carrying water, spirits, matches, wood, articles of wearing apparel, with apparatus for boiling coffee and broiling meat. The boat also carries a reflecting lamp, fire balls, blue lights, rockets, 300 feet of line, a horn, and alarm bell, and is steered by means of an oar. This boat has been satisfactorily tested in severe weather.

LIFE-BUOYS consist of two hollow copper cylinders, each as large as a pillow, and sufficient to support one man standing on them: they are connected to each other. Should more than one person require support, they can lay hold of rope beckets fitted to the buoy, and so sustain themselves. Between the two copper vessels, there stands a hollow pole, or mast, into which is inserted, from below, an iron rod, whose lower extremity is loaded with lead, in such a manner that, when the buoy is let go, the iron slips down to a certain extent, lengthens the lever, and enables the lead at the end to act as ballast. By this means the mast is kept upright, and the buoy prevented from upsetting. The weight at the end of the rod is arranged so as to afford secure footing for two persons, should that number reach it; and there are, also, large rope beckets through which they can thrust their heads and shoulders, till assistance is rendered. At the top of the mast is fixed a port-fire calculated to burn about twenty minutes or half an hour; this is ignited most ingeniously by the same process which lets the buoy fall into the water; so that a man falling overboard at night is directed to the buoy by the blaze on the top of the mast. The person who has charge on board ship of the life-buoy sees it freshly primed every evening. In the morning the priming is taken out and the lock uncorked.

LIFE-PRESERVERS. Apparatus used at sea in case of persons falling overboard. Mr. Scheffer, of England, invented a cylindrical tubular ring without seam or break; it contains a stop cock and ivory pipe affixed; by this air can be blown in by the mouth and retained by the stop cock. When not inflated it folds up into a very small compass, suitable for the pocket, and weighs only twelve ounces.

An American invention of a similar character in the form of a straight cylinder of a caoutchouc water-proof material. The simplest form is a ring of caoutchouc to go round the body under the arm-pits, previously blown up with air.

LIGNIN. The woody fibre. This most important proximate principle of vegetables exhibits itself in a variety of forms, constituting the different textures of hard and soft wood: and various fibrous products, such as hemp, flax, cotton, &c. When by fine mechanical division it is reduced to a pulpy state, it is formed into paper. When, by different reagents, all the soluble matters are extracted from wood, the insoluble residue is lignin: its ultimate components are charcoal, oxygen, and hydrogen, the latter elements being in the same ratio as in water; so that wood may be considered as a compound of carbon and water, and according to Dr. Prout's experiments, almost exactly in equal weights. Lignin is very imperishable; but under certain circumstances it is attacked by *dry rot*, arising out of the growth of a parasitic fungus, which causes its rapid decay. Damp timber, in situations where air has not free access, is particularly subject to its attacks; and when once it has made its appearance, the well-seasoned timber in its neighborhood becomes liable to the same disease. The dry rot may be prevented by impregnating the timber with certain saline solutions, and of these a solution of corrosive sublimate has been found most effectual: the chloride combines chemically with the lignin, and the compound is very indestructible. See KYANIZING. Lignin has also a strong attraction for alumine; and hence linen, cotton, paper, and other forms of this fibre, may be aluminized by steeping them in hydrated alumine, diffused through water; or, more effectively by soaking them in certain aluminous solutions, drying them, and afterwards washing out the excess of the salt. It is in this way that cotton goods are impregnated with alumine for the purpose of dyeing and calico printing. Other metallic oxides exhibit similar attractive powers, especially the oxide of iron.

The analogy that exists between the composition of sugar, gum, starch, and even vinegar and lignin, suggests the possibility of the conversion of those proximate elements into each other; and it has accordingly been found that by carefully roasting pure and fine sawdust, it is rendered partially soluble in water, and that a part of it is converted into a nutritious substance, probably intermediate between sugar and starch; and which when mixed with a little flour, yields a palatable bread, not very unlike that made by some of the inhabitants of the northern parts of Europe of the bark of trees. Mixed with sulphuric acid, lignin passes into gum; and from this sugar may be obtained by boiling it for some hours in a very dilute sulphuric acid; this sugar, when purified, much resembles grape or honey sugar. By this process rags may be converted into nearly their own weight of this peculiar saccharine matter.

The production of vinegar by the destructive distillation of wood was originally suggested about the middle of the 17th century, by Glauber, a celebrated

German chemist of that time; it has lately become a very important branch of manufacture in this country. Upon the whole, there are very few natural products equally important with lignin in their applications to the useful and ornamental arts.

LIGNITE. Wood converted into a kind of coal, by being placed under ground in a damp situation.

LIGHT. The philosophical consideration of this imponderable element, as it used to be termed, but more properly now an affection of the ether pervading all space, does not belong to a treatise on the Useful Arts. The practical applications and various kinds of artificial lights are those points only which can be touched on. Under the articles Candle, Gas, and Lamps, the subject of artificial light has been alluded to. It is proper here to note a few other forms: of these the *Drummond Light* stands foremost. This light arises from exposing a globule or pea of lime to ignition in a blow-pipe, consuming oxygen and hydrogen. It resembles the focus of a reflector in the sun, and has already been applied to the microscope as a substitute for the sun, and by Lieut. Drummond to the illumination of light-houses, instead of Argand burners. The ignition lasts from 15 to 25 minutes, when new globules are inserted. From a small ball, only three-eighths of an inch in diameter, so brilliant a light is emitted that it equals in quantity about 18 Argand lamps, or 120 wax-candles; while, in intensity or intrinsic brightness, it is 260 times that of an Argand lamp. Some idea of its intense light may be gained from the fact that when the Ordnance Survey of Ireland was being made, it was necessary to have a fixed point of observation, which might be seen at some distance. This light was usually placed on a hill, and with the telescope its light in the day time was discernible 30 miles off. In revolving lights, such as that of Beachy Head, England, there are no less than 30 reflectors, 10 on each side. A single reflector, therefore, illuminated by a lime-ball, for each of these 10 is 26 times greater than that of the 30. This method was tried lately at Purfleet, off the English coast, in a temporary light-house, erected for the purpose of experiments by the Corporation of the Trinity-house, and its superiority over all the other lights with which it was contrasted was fully ascertained and acknowledged. On an evening, when there was no moonlight, and the night dark, with occasional showers, the appearance of the Purfleet light, viewed from Blackwall, a distance of 10 miles, was very splendid. Distinct shadows were discernible, even on a dark brick-wall, though no trace of such shadows could be perceived when the other lights, consisting of seven reflectors, with Argand lamps, and French lenses, were directed on the same spot. Another striking and beautiful effect, peculiar to this light, was discernible when the reflector was turned, so as to be itself invisible to the spectator; a long stream of rays was seen issuing from the spot where the light was placed, which illuminated the horizon to a great distance. As the reflector revolved, this immense luminous cone swept the horizon, and indicated the approach of the light, long before it could itself be seen from the position of the reflector.

The same balls have been substituted for sunshine, by Carey, of London, in very powerful microscopes, and are constantly on exhibition in museums. The Drummond Light is well adapted for the Magic Lantern illustrations.

Gillard Light.—M. J. P. Gillard, a French gentleman, has taken out a patent in England, in 1849, for improvements in the production of heat and light in general.

The patentee's invention consists in certain apparatus and processes for producing hydrogen gas, by the decomposition of water, and its application to heat and light. The means and processes by which he obtains this gas are: 1. By the incandescency of iron. 2. By carbon. 3. By magnesia.

His improved process for rendering hydrogen gas illuminating, is by causing a small jet of lighted hydrogen to pass through a burner (the holes very small) on a thin strip of platinum wire, the threads being excessively fine, and of graduated section, proportioned to intensity of the pressure of the flame and the burning hydrogen,—a very powerful light is thus produced. The platinum threads are immediately heated to such whiteness that the luminous refulgence is extraordinarily brilliant. Besides platinum, other unalterable and unoxidizable metals may be employed. The wick must be of the shape necessary to agree with that of the jet of hydrogen,—it may be that of a cone, or any other figure, according to the size which the gas takes when it is allowed egress from the burner; the wick must be made more or less strong, according to the greater or less intensity of the heat to which it is exposed. The burner and wick may be modified in their shape,—the patentee does not limit himself as regards the strength, the length, or the height of the wick, provided the principle of his invention be retained.

The invention of M. Gillard has been introduced into Manchester by Mr. Kurz, whose chemical works are at Cornbrook, Hulme, England.

The following is a plan adopted in the new process:—An inch pipe is connected with the steam-boiler used in the general manufacturing process carried on at the works; and thence runs back to the retort furnace, passing underneath the fire bars, and passing up the front of the furnace, to the level of the bottom of a common D retort, about a foot internal diameter. A ¾ inch pipe is then carried the whole length of the interior of the retort; the underside of the pipe is perforated with three rows of fine and closely-arranged holes, those of the centre row being perpendicular, and the others slanting outwards. The retort having been brought to a white heat, its bottom being covered with broken charcoal, the steam being admitted, the gas is freely produced. From the retort, the water gas is passed along through ordinary purifiers (the same in fact that have been long used at the works), and the effects are, that the water remains perfectly sweet and clear, but slightly carbonated, and the lime is converted into chalk. The gas is not yet generally used in Mr. Kurtz's works; but in a cellar about 26 yards long and eight or ten broad, three ordinary argand burners (with an addition, to which we shall refer) give considerably more light, of a more pleasing character, than would ordinarily be required in such a place for mercantile purposes, or would be produced by a dozen batswing lights with ordinary gas. A newspaper could be read with ease, at a distance of 40 ft. to 45 ft. by the light from a single burner, with a reflector. The fact of the possibility of producing a gas from a decomposition of water has been known to scientific men for 50 or 60 years; the question has been, how to render it available for the purposes of illumination. M. Gillard's invention, for this purpose, consists of a small circular cage of very fine platina wire, worked in a similar manner to the material for a fancy basket. This cage of wire is attached to a small brass frame, fitting on to the burner, so that the lower edge of the cage is brought immediately over, and at a small distance from the perforations in the burner. Without the wire-work, the gas burns similar to a large spirit-lamp, emitting a great heat, but perfectly useless as a means of illumination. But instantly on the addition being made, the flame apparently changes into a column of intensely white light over the whole surface of the wire-work, with a slight appearance of an inner flame rising rather above it. The latter, however, disappears when a glass is added, and there is then not a particle of smell or smoke emitted. One burner in the counting-house has been found, by a rough calculation, to consume from 7½ to 8½ cubic feet of gas per hour; and with the consumption a photometer shows that its light is about 12 times as powerful as that given by one of the largest kind of composite candles. With regard to the injury to the platina wire-frame, M. Gillard states that there are some at Paris which have been almost continually used for five years, without having suffered in the slightest degree; and his conviction is, that with pure water gas, the wire would remain uninjured for an indefinite period. If one of the platina frames be placed over a common gas light, it is very soon destroyed; the frames used are about 1½ in. deep and ¾ in. in diameter. The heat thrown out by the gas is very great, but it is wholly devoid of smoke or smell; and on the hand being held over one of the flames, the sensation is rather that produced by steam, or hot vapor, than the dry, scorching feeling, caused by common gas. An experiment has been tried, of burning a large jet inside a shade on the hearth-stone, and the heat diffused was most pleasant and genial, the effect being felt in every part of the room almost instantly on the gas being lighted. A large pan of water was made to boil by the flame from this burner in a minute and a half; and an intention has been mentioned of attaching to the pipe a flexible tube, and by this means boiling water on the breakfast, tea, or supper table. It is intended by Mr. Kurtz to have the whole of his house warmed by the gas, and stoves fitted up for all culinary purposes; M. Gillard stating, positively, as the result of experiments, that he can by means of his gas roast a fowl in five minutes, or a leg of mutton in fifteen minutes.

LIME. The oxide of calcium, one of

the metals of the earths. This very useful earth is obtained by exposing chalk and other kinds of limestone, or carbonates of lime, to a red heat—an operation generally conducted in kilns constructed for the purpose; the carbonic acid is thus expelled, and lime, more or less pure, according to the original quality of the limestone, remains. In this state it is usually called *quicklime*. When sprinkled with water it becomes very hot, and crumbles down into a dry powder, called *slaked lime*, or *hydrate of lime*. When exposed for some weeks to the air it also falls into powder, in consequence of the absorption of moisture, and of a portion of carbonic acid; so that, in this case, part of the lime gradually reverts to the state of carbonate, and loses its causticity. Pure lime may be obtained by heating powdered Carrara marble to whiteness in an open crucible. It is white, very fusible, highly luminous when heated to full redness, and of a specific gravity of about 2·3. It requires for solution about 500 parts of water, and is somewhat more soluble in cold than in hot water. But, weak as this solution is, it acts powerfully alkaline upon vegetable colors, and has an acrid taste; hence the term *alkaline earth* applied to lime. It absorbs carbonic acid by exposure to air, and as *carbonate of lime* is insoluble in water, it becomes milky in consequence; so that, from this property, lime-water is a useful test of the presence of carbonic acid. The nature of lime was first demonstrated by Davy in 1807: he showed that, like the other alkalies, it was a metallic oxide. The metallic base of lime has been termed *calcium:* its equivalent is 20, and lime, being a compound of one atom of calcium, and one of oxygen, is represented by the equivalent number 28; and hydrate of lime by 28 lime + 9 water = 37. The *salts of lime* are generally obtained by dissolving carbonate of lime in the respective acids: several of them exist native. *Sulphate of lime*, selenite, or gypsum, is an abundant natural product, and may be formed artificially by adding sulphuric acid, or the soluble sulphates, to solutions of the salts of lime. It consists of 28 lime + 40 sulphuric acid, and its crystals include two atoms = 18 of water. When these crystallized sulphates of lime are heated, they part with their water and fall into a white powder, called *plaster of Paris;* when this is mixed with water it again combines with it, and concretes into a white mass: hence its use for casts, busts, &c. Sulphate of lime is often contained in spring water, which is thus rendered *hard* and unfit for washing. These waters become turbid upon the addition of a spirituous solution of soap. *Phosphate of lime* is found *native*, constituting the mineral called *apatite:* this is a *subphosphate*, composed of 3 equivalents of lime = 84, and 2 of phosphoric acid = 72 The *earth of bones* is also chiefly a similar phosphate of lime. *Oxalate of lime* is very insoluble, and is precipitated whenever oxalic acid or a solution of oxalate is added to solutions containing lime; hence it is that oxalate of ammonia is so valuable a test of the presence of lime, and is frequently used for the purpose of separating lime in analysis. When oxalate of lime is well dried, at 500°, it is anhydrous, and consists of 28 lime + 36 oxalic acid = 64 oxalate of lime. This substance is occasionally found in the human urine, and sometimes forms calculi. These are often of a reddish brown color and a rough exterior, whence they have been termed *mulberry calculi.* When hydrate of lime is exposed to chlorine, the gas is absorbed, and a *chloride of lime* is obtained. This article is manufactured upon an extensive scale, under the name of *bleaching powder*. It evolves chlorine when acted upon by acids; and gives it out very slowly when exposed to air, in consequence, probably, of the absorption of carbonic acid. It is a most useful disinfecting material, and, when dissolved in water, forms *bleaching liquid*. *Carbonate of lime* is thrown down when alkaline carbonates are added to solutions of the salts of lime. It is a most abundant natural product, and is found pure in the varieties of calcareous spar and statuary marble. Chalk and several varieties of limestone are also nearly pure carbonates of lime. It is easily distinguished from other minerals by effervescing in dilute muriatic acid, and by yielding quicklime when a fragment is heated before the blowpipe. It is constituted of 28 lime + 22 carbonic acid; the equivalent, therefore, of carbonate of lime is 50.

The uses of lime are very numerous. Its most important application is in the manufacture of mortar and other cements used in building. It is also very extensively used in this country as a manure to fertilize land. But it is a curious fact that the use of lime as a manure is entirely a European practice, its employ ment in this way having been never so much as dreamed of by the natives of Asia or Africa.

Native preparations of lime.—1. Calc Spar, in colorless crystals, is scratched by the nail. Spec. grav. 2·7.

2. Stalactitic, or concretionary carbonate of lime, composed of fibrous bands, undulated and parallel. These are found in caves and vaults, being formed by the dropping of water highly charged with limestone and carbonic acid. That which remains on the roof is called *stalactite*, that which forms on the ground is called *stalagmite*, or oriental alabaster: its rings are spread out of a reddish yellow color, with distinct zones, and susceptible of a fine polish. This alabaster is made into furniture ornaments.

3. Calcareous tufa are incrustations of carbonate of lime upon vegetable remains made by the deposition of calcareous petrifying rivulets. It is porous, cellular, soft, impure, and of a dirty gray color; it is rough and irregular. The incrustations are occasionally so large, that buildings are made of them. The *travertino* with which the monuments of Rome are made, are deposits from the Anio. They harden in the air.

4. Compact limestone has an even grain; does not polish or afford large blocks—to this class belongs the Magnesian limestone, or zechstein, in which the lithographic limestone is included according to Brogniart.

5. Oolite or roe stone, found in small grains of various size.

6. Chalk. Neither of these two varieties exist to any extent on this continent.

7. Marly limestone, very common on clay slate lands, and in basin-shaped lakes, and fresh water formations. This crumbles in the air: it must not be confounded with common marl.

8. Siliceous limestone, compact, scratches steel; leaves insoluble silica when acted on by hydrochloric acid.

9. Calp, fine grained, compact, hard, blue-black in color; leaves silica and alumina when acted on by acid; found in extensive beds.

10. Bituminous limestone, found near the coal formations; of a blue color, burns white.

Of all common limestones the purity may be most readily determined by the quantity of carbonic acid which is evolved during their solution in dilute nitric or muriatic acid. Perfect carbonate of lime loses in this way 46 *per cent.*; and if any particular limestone loses only 23 *per cent.*, we may infer that it contains only one half its weight of calcareous carbonate. This method is equally applicable to *marls*, which are mixtures in various proportions of carbonate of lime, clay, and sand, and may all be recognized by their effervescing with acids.

The chief use of calcareous stones is for procuring quicklime by calcination in proper furnaces; and they are all adapted to this purpose provided they are not mixed with too large a proportion of sand and ferruginous clay, whereby they acquire a vitrescent texture in a high heat, and will not burn into lime. Limestone used to be calcined in a very rude kiln, formed by inclosing a circular space of 10 or 15 feet diameter, by rude stone walls 4 or 5 feet high, and filling the cylindrical cavity with alternate layers of turf or coal and limestone broken into moderate pieces. A bed of brushwood was usually placed at the bottom, to facilitate the kindling of the kiln. Whenever the combustion was fairly commenced, the top, piled into a conical form, was covered in with sods, to render the calcination slow and regular. This method being found relatively inconvenient and ineffectual, was succeeded by a permanent kiln built of stones or brickwork, in the shape of a truncated cone with the narrow end undermost, and closed at bottom by an iron grate. Into this kiln, the fuel and limestone were introduced at the top in alternate layers, beginning of course with the former; and the charge was either allowed to burn out, when the lime was altogether removed at a door near the bottom, or the kiln was successively fed with fresh materials, in alternate beds, as the former supply sunk down by the calcination, while the thoroughly burnt lime at the bottom was successively raked out by a side door immediately above the grate. The interior of the lime kiln has been changed of late years from the conical to the elliptical form; and probably the best is that of an egg placed with its narrow end undermost, and truncated both above and below; the ground plot or bottom of the kiln being compressed so as to give an elliptical section, with an *eye* or draft-hole towards each end of that ellipse. A kiln thus arched in above gives a reverberatory heat to the upper materials, and also favors their falling down in proportion as the finished lime is raked out below; advantages which the conical form does not afford. The size of the draft-notes for extracting the quicklime, should be proportionate to the size of the kiln, in order to admit a sufficient current of air to ascend with the smoke and flame, which is found to facilitate the extrication of the carbonic acid. The kilns are called *perpetual*, because the operation is carried on continuously as long as the building lasts; and *draw-kilns*, from the mode of discharging them by raking out the lime into carts placed against the draft-holes. Three bushels of calcined limestone, or lime-shells, are produced on an average for every bushel of coals consumed. Such kilns should be built up against the face of a cliff, so that easy access may be gained to the mouth for charging, by making a sloping cart road to the top of the bank.

Limestone may be burned in the field in heaps, with coal, where it is quarried, or where the lime is to be used, 30 bushels of coal to 100 of limestone are used, the two being interstratified for burning. Flues are dug in the ground, and the heaps or piles may be made of any desired size: their bases are usually 10 to 15 feet wide, and are carried up in somewhat of a gothic arch shape, to a point or ridge, so as to make the height about the same as the base. The quantity of coal used is in the proportion of about one ton of coal to 100 bushels of limestone—if the coal is fine and slaty, a somewhat larger proportion is used. The length of the piles is made to correspond with the quantity of lime desired at one time, say from 20 to 100 feet in length. The ground flues, which are about 12 or 18 inches square, are extended to about 3 feet out on each side, to admit the wood which is burned in them to start the fire and ignite the coal in the heap, which usually takes 4 to 6 hours, and about half a cord dry wood to 1000 bushels of coal. After the pile is constructed it is plastered over to within about 18 inches of the top on each side, with wet plaster mortar made of clay; this covering is from 3 to 5 inches thick. About 1½ feet of the top heap is constructed of small stones or stone chips, and is left uncovered until the fire is fully started, then covered over with dry dirt to keep down a too rapid combustion. The clay coat is put on before firing, and is kept plastered over close during the burning. The outside courses of stone are set on edge in an oblique manner, the direction of their inclination being changed each course, which form a zigzag appearance. The outside courses are laid with care, taking stone of about the same size, but the interior, after the first 2 or 3 courses, is filled up with stone of all sizes, to the extent of 80 pounds, but each coat of coarse stone is filled up and levelled over with small stone of more uniform size—say as large as the first, and then the course of coal is strewn over the smaller stones before another course is added. The first three courses are of about a uniform size of half a brick, and covered with a larger proportion of coal than the courses higher up, the depth or thickness of which is progressively increased to 15 or 18 inches in the body of the piles. As the courses are made thicker, so are stone used of larger size—but the coarse stone are to be levelled up and covered with smaller stone to receive the strata of coal.

The ground flues are covered with stone, which are large enough to reach across and lap 4 to 6 inches on each side of the ditch, or the stone may be projected from either side to meet in the middle of the flue—having sufficient bearing on each side of the flue or ditch to keep them from tilting into the flue when laid. Over these stone, and throughout the whole base of the pile, is laid a covering, say 3 or 4 inches thick, of dry wood, and on this is about 2 inches in depth of mineral coal spread over, then a course of limestone, say size of half a common brick. Coal and limestone are thus alternated for two or three courses, then the thickness of each course is gradually increased as we raise in height.

In some places, where coal is scarce, wood or peat is used, and these are to be placed in layers, alternate with the lime, in a conical or egg-shaped form, covered with clay, and 5 or 6 yards in diameter, with a funnel of dry brushwood down the centre, two feet wide. The pile is fired from the top of this funnel, which will burn down to the bottom, and set the whole in combustion.

The best form of the kiln is the egg shape, and wood is preferred to coal in the burning. A lime-kiln should always be built high, and the diameter according to the height. By burning chalk in a kiln, good lime is the result. After limestone is burned, it is much lighter than before, but it recovers its weight in a great measure when exposed to the air, as it absorbs carbonic acid therefrom. The burning of lime is any thing but an agreeable or healthy business, but like many others it is very useful and necessary.

There is one thing curious about limestone, viz., if it be imperfectly burned in the first instance, and the stone cooled, no subsequent burning will make it into quicklime. In agriculture, lime is a great fertilizer, by hastening the decomposition of vegetable matter; and as all marl is a species of lime, it would be the better for being burned before it is used, if the object of adding be to hasten that decomposition.

Quicklime is employed in a multitude of preparations subservient to the arts; for clarifying the juice of the sugar-cane and the beet-root; for purifying coal gas; for rendering the potash and soda of commerce caustic in the soap manufacture, and in the bleaching of linen and cotton; for purifying animal matters before dissolving out their gelatine; for clearing hides of their hair in tanneries; for extracting the pure volatile alkali from muriate or sulphate of ammonia; for rendering confined portions of air very dry; for stopping the leakage of stone reservoirs, when mixed with clay and thrown into the water; for making a powerful lute with white of egg or serum of blood; for preparing a depilatory pommade with sulphuret of arsenic, &c. Lime water is used in medicine, and quicklime is of general use in chemical researches. Next to agriculture the most extensive application of quicklime is to MORTAR-CEMENTS, which see.

In the employment of lime in agriculture much empiricism has been used, and ground has been as much injured as benefited by its use. The majority of cultivated crops require lime, and it is found in their ashes when burned: hence if the soil do not contain lime these plants cannot grow. If the soil be deficient in lime or only present in small quantity, lime is serviceable; if it be very clayey lime is also desired. If much vegetable matter be present lime is necessary to make it pass through the decompositions useful for plants that is to form carbonic acid. This is the main use of lime: if there be a small amount of organic matter present, lime will be injurious and the ground will become poorer; the addition of lime should always be in proportion to the quantity of organic matter present. Lime is more used in England than on this continent, and appears to be more required, it contributing to warm the soil and force the plant, processes performed by a less obscured sun here. Wheat scarcely grows well on English land, which does not contain 2½ per cent. of lime as carbonate, while some of the richest land of the Genesee Valley contains less than one-half per cent. An ordinary dressing of caustic lime varies from 80 to 100 bushels. Marls may be laid on much heavier.

LIME, HYPOSULPHITE OF. A salt now used in the refining of sugar; it may be prepared in the following way:—Boil together an excess of lime and sulphur with water in any convenient vessel until the mixture assumes a deep red color, and then allow it to settle for some time. The clear solution contains a mixture of hyposulphite of lime and sulphuret of calcium. To this clear solution sulphurous acid gas (vapors of burning sulphur) is to be added until the red color disappears, and no further deposit will take place, when considerable sulphuric acid is added when in a cold state. The solution is then filtered and the clear fluid forms the hyposulphite of lime, and it is used for defecating saccharine matters. When this solution is used it is mixed with eight parts of water.

LINEN. A species of cloth woven with the fibres of the flax plant (*Linum usitatissimum*). The origin of the manufacture of linen is lost in its antiquity. In the time of Herodotus linen was an article of export from Egypt, where it had been used from time immemorial; but it is evident that in ancient times its use was limited to the noble and the rich. In modern times linen constitutes a staple manufacture in almost all European countries; but more especially in Germany, Russia, Switzerland, Flanders, England, Scotland, and Ireland. In England it has been prosecuted for a very long period: but until of late years its progress has been inconsiderable, compared at least with that made in other branches of manufacture. This seems to be partly owing to the attempts to bolster up and encourage the manufacture in Ireland, partly to the absurd restrictions that were for a lengthened period laid on the importation of foreign flax and hemp, and partly to the rapid growth of the cotton manufacture—fabrics of cotton having, to a considerable extent, superseded those of linen. It is only within the last fifty years that any machinery has been used in England in the production of linen cloth, the first mills for the spinning of flax having been constructed at Darlington about forty-eight years ago.

The entire value of the linen manufacture of Great Britain and Ireland is estimated at £8,000,000, and the total number of persons employed in it about 185,000.

One of the great obstacles which has stood in the way of the extended cultivation of flax, is the trouble, delay, and expense attendant on its steeping, and preparation for the market. This has been now removed by an invention which dispenses with that process, and enables the grower, at the smallest possible cost, to send his fibre into the market. By this process, of which Mr. Doulan is the inventor, the results are obtained by a combination of chemical and mechanical processes, and all expenses connected with steeping being avoided, the fibre may be prepared at a cost considerably below the present process, and may be made applicable for the coarsest nail bags, or canvas, or for the finest Brussels lace.

Not only the expense, but the time is also less, which is consumed in the preparation of the fibre. In the old way this occupied from 10 days to 3 weeks. By the unsteeped mode as many hours suffice. The fibre produced is also clean and in its natural state, and its strength is regular and uniform. These two last qualities being found to be constant in the unsteeped flax, has led to adaptation of it to cotton machinery. The patentee of the invention is the Chevalier P. Claussen, member of the Brazilian Institute, the inventor of the circular loom. The patent granted is for the preparation of flax in a short staple, so as to produce a substitute for wool and cotton, capable of being spun on cotton machinery; and also for the mixture of the materials thus obtained, which can be carded together with silk, cotton, or wool, or separately as cotton for spinning into yarn. The right is likewise secured for preparing long fibre as a substitute for silk, for bleaching in the preparation of materials, for spinning and felting, and also in yarns and felts. From 1½ cwt. of the flax fibre, prepared and cleaned upon the unsteeped process, 1 cwt. of a substance identical with clean cotton can be produced at a cost of 56 cents for materials. The cost of manual or mechanical labor required in the preparation, including the expenses of bleaching, an operation performed in a few seconds, does not amount to more than nineteen twentieths of a cent per pound. The mixture of the two substances, viz., wool with flax, reduced to short staple, forms a fabric exceedingly durable, while its cost may be judged by the fact, that while wool costs one dollar, the flax prepared and ready for spinning may be had for 12½ cents per lb.; so that with flax and wool spun together in equal quantities, the cost would be reduced by nearly one half.

LINE, in decimal measures the 10th, and in duodecimals the 12th of an inch, French or English; the French inch being to the English as 1 to 1·065977.

LINIMENT OF AMMONIA, is a mixture of equal parts of olive-oil and caustic-water of ammonia. It is a useful application for sore throats, rheumatic pains, &c. A stronger liniment is, two parts of olive-oil, with one solution of ammonia.

Liniment of camphor, is 4 olive-oil, 1 camphor. The compound liniment is, 8 solution of ammonia, and 8 spirit of lavender distilled, and 1 camphor dissolved, with ½ tincture of opium added.

Liniment for burns and scalds.—Take of borate of soda 1½ dr.; rose-water, 2 drs.; lime-water, 2½ oz.; oil of sweet almonds, 3 oz. Soak lint in this mixture, and apply to the affected parts. Turpentine is also a good liniment, or any spirits.

LINING. In architecture, any covering of an interior surface. The linings, for instance, or boxings of window shutters, are the pieces forming the backs of the recesses into which the shutters are folded. In doorways, they are the facings on each side the aperture: to sashes, they are the vertical pieces parallel with the surface of the walls.

LINSEED contains, in its dry state, 11·265 of oil; 0·146 of wax; 2·488 of a soft resin; 0·550 of a coloring resinous matter; 0·926 of a yellowish substance analogous to tannin; 6·154 of gum; 15·12 of vegetable mucilage; 1·48 of starch; 2.932 of gluten; 2·782 of albumine; 10·884 of saccharine extractive; 44·382 of envelopes, including some vegetable mucilage. It contains also free acetic acid; some acetate, sulphate, and muriate of potash, phosphate and sulphate of lime; phosphate of magnesia; and silica. (*See* OILS.)

LINTEL. In architecture, an horizontal piece of timber or stone, over a door, window, or other opening, to discharge the superincumbent weight.

LIP-SALVE (*white*). Melt together equal weights of white wax, white sugar-candy, spermaceti, and olive-oil.

Or (*red*). Melt together 4 oz. of white wax, 5 oz. of olive-oil, 4 drs. of spermaceti, and add 20 drops of oil of lavender, and 2 oz. of alkanet root. *Or*, 2 oz. of best olive-oil, 3 oz. of spermaceti and of white wax, with 4 drs. of alkanet root; melt, strain, and add 3 drops of oil of rhodium wood. *Or*, melt together 2 oz. of white wax, 3 oz. of spermaceti, and 6 oz. of oil of almonds, and add 1 oz. of alkanet root, and 2 drs. of balsam of Peru.

LIQUATION is the process of sweating out, by a regulated heat, from an alloy, an easily fusible metal from the interstices of a metal difficult of fusion. Lead and antimony are the metals most commonly subjected to liquation; the former for the purpose of carrying off by a superior affinity the silver present in any complex alloy, a subject discussed under SILVER.

LIQUID AMBER is the produce of the liquid-amber styraciflora, a tree which grows in Mexico, Virginia, and Louisiana. Occasionally it is of an oily consistence, at other times thick like turpentine. It is translucent, yellow, of a pleasant odor, and aromatic flavor, somewhat pungent. It dissolves almost in boiling alcohol. It contains much Benzoic acid, which exudes when the fluid hardens by keeping.

LIQUEURS, LIQUORISTE; names given by the French to liquors compounded of alcohol, water, sugar, and different aromatic substances; and to the person who compounds them. There are given here, on Dr. Ure's authority, a few of their most approved recipes.

Infusion of the peels of fruits.—The outer skin, pared off with a sharp knife, is to be dropped into a hard glazed jar, containing alcohol of 34° B., diluted with half its bulk of water, and the whole is to be transferred into well-corked carboys. After an infusion of six weeks, with occasional agitation, the aromatized spirit is to be distilled off. In this way are prepared the liquors of cedrat, lemons, oranges, *limettes* (a sort of sweet lemon), *poncires* (the large citron), bergamots &c.,

Infusion of aromatic seeds.—These must be pounded, put into a carboy, along with alcohol diluted as above, infused with agitation for six weeks, and then distilled.

Infusions of aromatic woods are made in the same way.

The liquorist should not bring his infusions and tinctures into the market till six months after their distillation.

Liqueurs have different titles, according to their mode of fabrication.

Thus *waters* are liquors apparently devoid of viscidity; *creams* and *oils* possess it in a high degree.

Water of *cedrat* is made by dissolving six pounds of sugar in seven quarts of water; adding two quarts of spirit of *cedrat*, and one of spirit of citron. Boil the whole for a minute, and filter hot through a proper bag. Set it for a considerable time aside in a corked carboy, before it be bottled.

Oil or cream of cedrat.—Take eight quarts of river water, two of spirit of cedrat, one of spirit of citron, and as much rich sirup as is necessary to give the mixture an oily consistence. Stir it well and set it aside in carboys. Should it be at all clouded, it must be filtered till it be perfectly pellucid.

Balm of Molucca, is made by infusing for ten days, in a carboy capable of holding fully four gallons, 10 pounds of spirits of 18° B., 4 pounds of white sugar, 4 pounds of river water, 4 drachms of pounded cloves, and 48 grains of pounded mace. The mixture is to be shaken 3 or 4 times daily, colored with caramel (burnt sugar), filtered at the end of ten days, and set aside in bottles.

Tears of the widow of Malabar, are compounded with the preceding quantity of spirits, sugar, and water, adding 4 drachms of ground cinnamon, 48 grains of cloves, and a like quantity of mace, both in powder. It may be slightly colored with caramel.

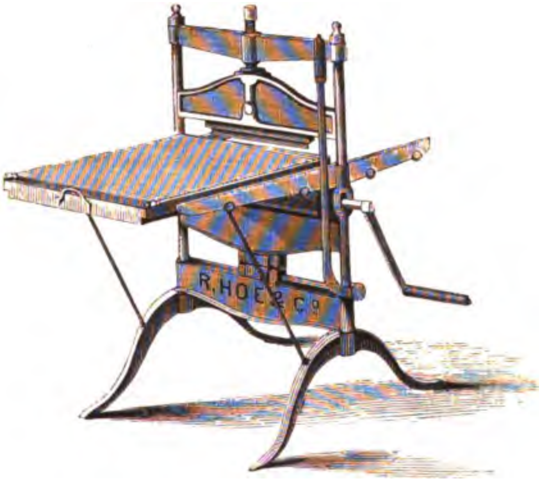
The delight of the Mandarins.—Take spirit, sugar, and water, as above, adding 4 drachms of *anisum Chinæ* (*Gingi*), as much *ambrette* (seeds of the *hibiscus abelmoschus, Lin.*), all in powder; 2 drachms of safflower.

The sighs of love.—Take spirits, water, and sugar, as above. Perfume with essence (otto) of roses; give a very pale pink hue with tincture of cochineal, filter and bottle up.

Crême de macarons.—Add to the spirit, sugar, and water, as above, half a pound of bitter almonds, blanched and pounded; cloves, cinnamon, and mace in powder, of each 48 grains. A violet tint is given by the tinctures of turnsole and cochineal.

Curacoa.—Put into a large bottle nearly full of alcohol of *trente-six* (34° Baumé), the peels of six smooth Portugal oranges, (Seville?) and let them infuse for 15 days; then put into a carboy 10 pounds of spirits of 18° B., 4 pounds of white sugar, and 4 pounds of river water. When the sugar is dissolved, add a sufficient quantity of the orange *zestes* to give flavor, then spice the whole with 48 grains of cinnamon, and as much mace, both in powder. Lastly introduce an ounce of ground Brazil wood, and infuse during 10 days, agitating 3 or 4 times daily. A pretty deep hue ought to be given with caramel.

LIQUORICE.—*Glycyrrhiza glabra*, the



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plant which produces the liquorice of the shops, is cultivated in England for the use of brewers and distillers, but liquorice is manufactured from it only in Sicily and Spain. It grows naturally near Pontefract and Languedoc, in all the Mediterranean countries, and in such abundance in Sicily that it is considered a great scourge to the cultivator. Its roots penetrate to a great depth, and the deeper the ground is opened, with a view to eradicate them, so much the more vigorous is the succeeding crop. The juice is expressed from the roots, in the same way as oil is from olives; they are first washed perfectly clean, then crushed in an olive mill, then boiled four or five hours, pressed in the olive-press, and the juice slowly boiled, and evaporated in an iron vessel.

LITHARGE, is the crystals of melted lead left to cool, and is formed also in the refinement of silver. It removes acidity in wines, but renders them highly pernicious, and the use of it is deeply criminal. It is a fused protoxide of lead.

LITHIA, a rare alkali, discovered by Arfwedson in a mineral called *petalite*. It is also found in spodumene, and a few other minerals. It is known from potash and soda by its carbonate being difficultly soluble—from baryta, strontia, and lime, by the solubility of the sulphate and oxalate, and from magnesia by its carbonate having alkaline properties. It is the oxide of the metal lithium; its equivalent is 10, and that of the oxide 18.

LITHIC, or *Uric acid*, one of the constituents of urine: in that of the serpent species it is found in great abundance. It exists largely also in guano, united with ammonia. Occasionally it is formed in excess in the system, and is thrown off by the kidneys undissolved, forming the uric acid calculus.

LITHIUM, is a white alkaline metal, lighter than potassium, and its oxide is the alkali called Lithia.

LITHOGRAPHY, is the art of throwing off impressions, upon paper, of figures and writing previously traced upon stone. It has been partly treated of under the head "engraving." The processes of this art are founded:—

1. Upon the adhesion to a smoothly-polished limestone of an encaustic fat which forms the lines or traces.

2. Upon the power, acquired by the parts penetrated by this encaustic, of attracting to themselves, and becoming covered with a printer's ink, having linseed oil for its basis.

3. Upon the interposition of a film of water, which prevents the adhesion of the ink in all the parts of the surface of the stone not impregnated with the encaustic.

4. Lastly, upon a pressure applied by the stone, such as to transfer to paper the greater part of the ink which covers the greasy tracings of the encaustic.

The lithographic stones of the best quality are still procured from the quarry of Solenhofen, a village at no great distance from Munich, where this mode of printing had its birth. They resemble in their aspect the yellowish white lias of Bath, but their geological place is much higher than the lias. Abundant quarries of these fine-grained limestones occur in the county of Pappenheim, along the banks of the Danube, presenting slabs of every required degree of thickness, parted by regular seams, and ready for removal with very little violence. The good quality of a lithographic stone is generally denoted by the following characters: its hue is of a yellowish gray, and uniform throughout; it is free from veins, fibres, and spots; a steel point makes an impression on it with difficulty; and the splinters broken off from it by the hammer display a conchoidal fracture. A new locality affording fine stone is at Belbéze, Haute Garonne, in French Pyrenees: they are found in the chalk formation, which is a peculiarity. This Continent does not as yet appear to contain any lithographic stone of good quality.

The Munich stones are retailed on the spot in slabs or layers of equal thickness; they are quarried with the aid of a saw, so as to sacrifice as little as possible of the irregular edges of the rectangular tables or plates. One of the broad faces is then dressed and coarsely smoothed. The thickness of these stones is nearly proportional to their other dimensions; and varies from an inch and two-thirds to 3 inches.

In each lithographic establishment, the stones receive their finishing, dressing, and polishing; which are performed like the grinding and polishing of mirror plate. The work is done by hand, by rubbing circularly a movable slab over another cemented in a horizontal position, with fine sifted sand and water interposed between the two. The style of *work* that the stone is intended to produce determines the kind of polish that it should get. For crayon drawing the stone should be merely grained more or less *fine*, according to the fancy of the draughtsman.

The higher the finish of the surface, the softer are the drawings; but the printing process becomes sooner *pasty*, and a smaller number of impressions can be taken. *Works in ink* require the stone to be more softened down, and finally polished with pumice and a little water. The stones thus prepared are packed for use with white paper interposed between their faces.

Lithographic crayons.—Fine lithographic prints cannot be obtained unless the crayons possess every requisite quality. The ingredients composing them ought to be of such a nature as to adhere strongly to the stone, both after the drawing has undergone the preparation of the acid, and during the press-work. They should be hard enough to admit of a fine point, and trace delicate lines without risk of breaking. The following composition has been successfully employed for crayons by M M. Bernard and Delarue, at Paris:—

Pure wax, (first quality)	4
Dry white tallow soap	2
White tallow	2
Gum lac	2
Lamp black, enough to give a dark tint	1
Occasionally copal varnish	1

A simpler ink is as follows: White soap 6 parts, white wax 6 parts, lamp black 1 part, well fused together.

Lithographic ink is prepared in nearly the same way, viz.: wax 16 parts, tallow 6 parts, hard soap 6 parts, shellac 12 parts, mastic 8 parts, Venice turpentine 1 part, lamp black 4 parts. These are to be ground and heated together carefully.

The use of *autographic paper* is an improvement in lithography, as it abridges labor and does away with the necessity of making the drawing on the stone reversed. The drawing is made on this paper and then transferred to the stone. The ink for this purpose must be fatter than that intended for the stone, and may be made of white soap and white wax of each 10 parts, mutton suet and lamp black of each 3 parts, shellac and mastic of each 5 parts. These are to be melted and well incorporated together.

Lithographic paper.—Lay on the paper, 3 successive coats of sheep-feet jelly, 1 layer of white starch, 1 layer of gamboge. The first layer is applied with a sponge dipped in the solution of the hot jelly, very equally over the whole surface, but thin; and if the leaf be stretched upon a cord, the gelatine will be more uniform. The next two coats are to be laid on, until each is dry. The layer of starch is then to be applied with a sponge, and it will also be very thin and equal. The coat of gamboge is lastly to be applied in the same way. When the paper is dry, it must be smoothed by passing it through the lithographic press; and the more polished it is, the better does it take on the ink in fine lines.

Transfer.—When the paper is moistened, the transfer of the ink from the gamboge is perfect and infallible. The starch separates from the gelatine, and if, after taking the paper off the stone, we place it on a white slab of stone, and pour hot water over it, it will resume its primitive state.

The coat of gamboge ought to be laid on the same day it is dissolved, as by keeping it becomes of an oily nature; in this state it does not obstruct the transfer, but it gives a gloss to the paper which renders the drawing or tracing more difficult, especially to persons little habituated to lithography.

The starch-paste can be employed only when cold, the day after it is made, and after having the skin removed from its surface.

A leaf of such lithographic paper may be made in two minutes.

In transferring a writing, an ink drawing, or a lithographic crayon, even the impression of a copper-plate, to the stone, it is necessary, 1, that the impression be made upon a thin and slender body like common paper; 2, that they may be detached and fixed totally on the stone by means of pressure; but as the ink of a drawing sinks to a certain depth in paper, and adheres pretty strongly, it would be difficult to detach all its parts, were there not previously put between the paper and the traces, a body capable of being separated from the paper, and of losing its adhesion to it by means of the water with which it is damped. In order to produce this effect, the paper gets a certain preparation, which consists in coating it over with a kind of paste ready to receive every delineation without suffering it to penetrate into the paper. There are different modes of communicating this property to paper. Besides the above, the following may be tried: Take an unsized paper, rather strong, and cover it with a varnish composed of:—

Starch	120 parts
Gum arabic	40 —
Alum	20 —

A paste of moderate consistence must be made with the starch and some water, with the aid of heat, into which the gum and alum are to be thrown, each previously dissolved in separate vessels. When the whole is well mixed, it is to be applied, still hot, on the leaves of paper, with a flat smooth brush. A tint of yellow color may be given to the varnish, with a decoction of the berries of Avignon, commonly called French berries by our dyers. The paper is to be dried, and smoothed by passing under the scraper of the lithographic press.

Steel pens are employed for writing and drawing with ink on the lithographic stones.

LITHOMARGE. Stone marrow, a variety of talc of various colors, and generally associated with magnesian minerals.

LITMUS is prepared in Holland from the species of lichen called *Lecanora tartarea*, *Rocella tartarea*, by a process which has been kept secret, but which is undoubtedly analogous to that for making archil and cudbear. The ground lichens are first treated with urine containing a little potash, and allowed to ferment, whereby they produce a purple red; the colored liquor, treated with quicklime and some more urine, is set again to ferment during two or three weeks, then it is mixed with chalk or gypsum into a paste, which is formed into small cubical pieces, and dried in the shade. Litmus has a violet-blue color, is easy to pulverize, is partially soluble in water and dilute alcohol, leaving a residuum consisting of carbonate of lime, of clay, silica, gypsum, and oxyde of iron combined with the dye. The color of litmus is not altered by alkalies, but is reddened by acids; and is, therefore, used in chemistry as a delicate test of acidity, either in the state of solution or of unsized paper stained with it. It is employed to dye marble blue.

LIXIVIATION signifies the abstraction by water of the soluble alkaline or saline matters present in an earthy admixture; as from that of quicklime and potashes to make potash ley, from that of effloresced alum schist to make aluminous liquors, &c.

LOADSTONE, MAGNETIC IRONSTONE. An iron ore consisting of the protoxyde and peroxyde of iron in a state of combination.

LOAM, contains 87 of sand as fine as meal, and 13 of clay, according to the analysis of Kirwan.

It is a natural mixture of clay and sand. The colored clays and loams participate of iron; hence, many of these melt in a strong fire, without any addition; both clay itself, and mixtures of it with crystalline earths, being brought into fusion by ferruginous oxides, though the fusible mixtures of clay and calcareous earths are, by the same ingredient, prevented from melting. The bricks made from some loams, are, when moderately burnt, remarkably free, so as to be easily rubbed smooth, cut, sawed, grooved, &c. Hence their use in building furnaces, &c.

LOCK, in Internal Navigation, is a part of a canal included between two floodgates, by means of which a vessel is transferred from a higher to a lower level, or from a lower to a higher.

On the Monkland Canal, at Blackhill Locks (Scotland), the waste of water, time, and labor, have been obviated by the substitution of a steep incline, with rails and water tight-cradles. The boat is floated into one of the latter, when it is drawn up by a wire rope worked with drums, by the power of a steam engine aided by the descending cradle filled with water. In five minutes a boat is hoisted up the incline, numbering eight large locks, at very little expense, and with the waste of no more water than that displaced by each boat when floated into its cradle. The engineer is a Mr. Leslie, of Edinburgh, who has adopted this plan from American practice.

LOCK. An instrument composed of springs and bolts, used to fasten doors, drawers, chests, &c. It is an improvement on the primitive latch or bolt, with a crooked stick or instrument, to turn it through a hole on the outside. Obstacles are opposed inside, and then the accommodating the key to pass them, constitutes its wards, the object being merely to turn and unturn a bolt, now called locking and unlocking. On the number and complication of the obstacles in cariyng the key to the bolt, so as to turn it, depends the perfection of the lock. The spring-lock consists of the main plate, the cover-plate, and the pin-hole. In, and on the main plate, is the key-hole, the top-hook, the cross-wards, the bolt-knob, the tumbler and its pin, and the staples. To the cover-plate is affixed the main, cross, and step-wards, and the pin. With the pin-hole are connected the hook, cross, and bow-wards, and the bit.

A good lock is the master-piece in smithery, and requires much art and delicacy in contriving and varying the wards, springs, bolts, and other parts whereof it is composed, so as to adjust them to the plates where they are serviceable, and to the various occasions of their use. The structure of locks is so varied, and the number of inventions of different sorts so extended, that we cannot attempt to enumerate them. Those placed on outer doors are called *stock* locks, those on chamber door *spring* locks, and such as are hidden in the thickness of the doors to which they are applied are called *mortise* locks. The padlock is too well known to need description. We here add the conditions which, to Mr. Nicholson, appear necessary in a lock of the most perfect kind: 1. That certain parts of the lock should be variable in position through a great number of combinations, one only of which shall allow the lock to be opened or shut. 2. That this last mentioned combination should be variable at the pleasure of the possessor. 3. That it should not be possible, after the lock is closed and the combination disturbed, for any one, not even the maker of the lock, to discover, by any examination, what may be the proper situations of the parts required to open the lock. 4. That trials of this kind shall not be capable of injuring the works. 5. That it shall require no key; 6. And be as easily opened in the dark as in the light. 7. That the opening and shutting should be done by a process as simple as that of a common lock. 8. That it should open without a key, or with one, at pleasure. 9. That the keyhole be concealed, defended, or inaccessible. 10. That they may be used by a stranger, without his knowing or being able to discover the adopted combination. 11. That the key be capable of adjustment to all the variations of the lock, and yet be simple. 12. That the lock should not be liable to be taken off and examined, whether the receptacle be open or shut, except by one who knows the adopted combination. These considerations involve a mechanical problem of great difficulty; but much towards its accomplishment has been effected in various inventions that have been promulgated, and more especially in those of Bramah, Chubb, Taylor, &c.

LOCOMOTION. Such motion as is attended by change of place in the body which moves, in contradistinction to motions which a body may have which is stationary. Thus, a clock, a mill, a lathe moves; but no change of place of the machine is produced: such *motion* is not locomotion. A steam engine which being fixed in its position, impels others bodies, is a stationary engine; but one which travels with the bodies which it drives is called a *locomotive* engine.

LOCOMOTIVE ENGINE. Any engine which, being employed to draw loads in transport overland, travels with the load which it draws.

Since the improvement and extension of iron railways, this term has been exclusively applied to the steam engine, by which loads are drawn upon them. Although, strictly speaking, the steam engine by which a ship is propelled is a locomotive engine, it is not usual to apply that term to it; such an engine is called a marine engine. (See STEAM NAVIGATION.) The term locomotive engine must, therefore as at present used, be understood to mean the travelling steam engine by which trains are drawn on railways.

History of the Locomotive Engine.— The first practical application of the steam engine as a locomotive power took place in 1804, on a railroad at Merthyr Tydvil, in South Wales. The engine was constructed by Messrs. Trevethick and Vivian, under a patent obtained by them two years previously. This engine, in several respects, resembled in its form and structure those which have been since used for a like purpose.

The boiler was a cylinder, with flat circular ends placed upon its side. A large tube entered it at one ene end, and, being carried near the other, was there received and carried back parallel to its first direction; its course through the boiler resembling the letter U. The two mouths or openings of this tube were therefore placed at the same end of the boiler. One of the mouths of this tube communicated with the chimney, the base of which was flanged upon it, and the other contained the grate and furnace. The flame and heated air were drawn through the curved tube, and up the chimney. The engine was worked by high-pressure steam without condensation; the steam being admitted to the cylinder, and withdrawn from it, by the well-known mechanical contrivance called a four-way cock. The cylinder was placed on its side; and in one position of the cock a communication was opened between the boiler and one end of the cylinder, while another communication was opened between the other end of a cylinder and a tube leading to the chimney. Steam was thus admitted to act on one side of the piston, and allowed to escape from the other side to the chimney. When the piston attained the end of the stroke the position of the cock was reversed, and the steam which had just driven the piston in one direction was allowed to escape to the chimney, while steam from the boiler was admitted on the other side of the piston, to impel it in the contrary direction; and in this manner the piston was continually driven backwards and forwards, in a horizontal direction, and parallel to the direction of the load. The piston rod was moved through a hole corresponding with it in magnitude, in the cover of the cylinder, in which it was rendered steam tight by a stuffing box properly lubricated. The piston rod acted by means of a connecting rod on a crank, which it kept in revolution in the same manner as the crank in a common double-acting steam engine is moved. (*See* STEAM ENGINE.) On the axle of this crank was placed a cogged wheel which by means of ordinary gearing, conveyed motion to the axle of the hind wheels of the engine, so as to keep that axle in constant revolution. The wheels being keyed upon that axle, so as not to be capable, like the wheels of a common carriage, of turning upon it were necessarily made to revolve with it; and so long as their pressure upon the road was sufficient to prevent them from slipping, a progressive motion of the carriage was the necessary consequence of their revolution.

The early projectors of locomotive engines were all impressed with a notion that the adhesion of the driving wheels with the rails must be insufficient to enable the power applied to these wheels to give progressive motion to the carriage; and, without thinking it necessary to ascertain by actual experiment, whether such were really the case or not, they expended much ingenuity and capital in devising means of overcoming this difficulty, which, after all turned out to be merely imaginary. Engineers were, in fact, impressed with a notion that if any power compelled the wheels to revolve, they would merely slip upon the rails, and that the carriage or engine would remain stationary. To provide against this, Messrs. Trevethick and Vivian proposed to make the external rims of the wheels intended for common roads rough and uneven, by surrounding them with projecting heads of nails or bolts, or by cutting traverse grooves in them. Seven years afterwards, Mr. Blinkensop, of Leeds, obtained a patent for a method of surmounting this imaginary difficulty by the substitution of a rack rail for the ordinary smooth rail, and constructing teeth to the driving wheels to work in the teeth in this track Various other ingenious contrivances were subsequently produced for the same purpose, until about the year 1814, when experience at length forced upon engineers the knowledge of the fact, that the adhesion of the tires of the wheels with the rails was amply sufficient to propel the engine, even when drawing after it a great load.

In 1814, an engine was constructed at Killingworth colliery, near Newcastle, having two cylinders with a cylindrical boiler, and working two pair of wheels by cranks placed at right angles, so that when one was in full operation, the other was at its dead points. By these means the propelling power was always in action. The cranks were maintained in this position by an endless chain, which passed round the two cog wheels placed under the engine, and fixed on the same axles on which the wheels were placed. The wheels in this case were fixed on the axles, and turned with them.

In an engine subsequently constructed by Mr. Stevenson for the same railway, the mode adopted of connecting the wheels by an endless chain and cog wheels was abandoned, and the same effect was produced by connecting the two cranks by a straight rod. This method is still used in the coupled engines which are applied to draw the trains of merchandise on the present railways.

The next stimulus which the progress of this invention received, arose from the project of constructing a railway between Liverpool and Manchester, for the purpose of general traffic. When this project was undertaken it was not decided what moving power was most eligible—whether horse power, stationary steam engines, or locomotive engines: but the first for many obvious reasons, was soon rejected, in favor of one or other of the last two.

The steam engine may be applied to move carriages on a railway by two distinct methods. By one, the engine is fixed and draws a train of carriages towards it by a rope extending the whole length of the road on which the engine works. By this method the line is divided into a number of short stages, at the extremity of each of which an engine is placed. The wagons or carriages, when drawn by an engine to its station, are detached, and connected with the extremity of the rope-work by the next stationary engine, and thus the journey is performed from station to station by separate engines. By the other method, each load transported along the line is drawn by an engine which travels with it as horses travel with a carriage on a common road.

Until the period to which we now advert, railways had been almost exclusively confined to the transport of mineral products from the mines up to the places of shipment, and to this purpose exclusively had the locomotive engine been applied ; but the ends to be attained by a railway of thirty miles in length, connecting the largest manufacturing town, in the greatest manufacturing country in the world, with the greatest, most active, and most opulent commercial port, were of a nature so much more extensive and important, that it was considered that more than ordinary means should be resorted to to obtain a moving power commensurate with the traffic which might be expected under such circumstances. Prizes were therefore proposed to be given, under certain stipulations, to those who would construct the most effective locomotive engines for the purposes of the road. This proposal produced, as was anticipated, much competition ; and the spirit of emulation being roused, a trial was appointed, which took place on the railway in October, 1829. Engines of several forms were produced; and the prize was awarded to one, called the *Rocket*, constructed by Mr. Robert Stevenson, the son of Mr. George Stevenson, the engineer of the railway. In the first trial, this engine attained the then astonishing speed of twenty-nine miles an hour; and when, unhappily, at the ceremony of the opening of the railway, the accident occurred which deprived the country of Mr. Huskisson, his wounded body was conveyed by the same engine, a distance of about fifteen miles in twenty-five minutes, being at the rate of thirty-six miles an hour.

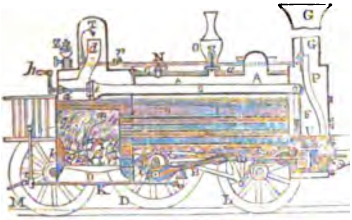
The circumstances in this mechanical arrangement, on which the rapid production of steam depends, are two-fold : first, the extensive surface exposed to the radiant heat of the fire, by the casing surrounding the fire box, and by the tubes, twenty-five in number and only three inches in diameter, by which the flame and heated air are conducted through the boiler from the fire box to the chimney ; and, secondly, by the powerful draught maintained in the furnace by the current of steam constantly discharged up the chimney. It has been mainly by bringing these principles more fully into operation, that all the improvements since made in the locomotive engine have been effected.

The railway was not long in operation, when the arrangement of the tubes in the boiler was improved ; their number was increased from twenty-five to one hundred and upwards, and their diameters diminished from three inches to an inch and a half. This change alone produced an increased efficiency of the fuel, the proportion of nearly two to one ; the consumption of coke in the Rocket having been very nearly 2½ pounds per ton per mile, while, by the change above mentioned, the consumption of fuel in the new engines was reduced to 1¼ pound per ton per mile. The position of the cylinder was also advantageously changed. Instead of being placed, as in the Rocket, outside the boiler, and exposed to the cold air, through which the engine passed with such a velocity, they were now placed in that part of the engine called the *smoke box*, an enclosed space at the base of the chimney, into which the flame and heated air escaping from the tubes passed. By this arrangement the cylinders were always maintained as hot as the air which issued from the flues, and all condensation of steam by their exposure prevented.

As the cylinders were now placed between the wheels, their operation could not be effected in the same manner as in the Rocket. The connecting rods were accordingly made to act on two cranks, constructed upon the axle of the wheels, placed at right angles to each other, so that one may always be at its dead point, while the other was in full action. This double-cranked axle was, from the weakness consequent upon its form, liable at first to fracture ; but improved methods of forging them subsequently gave them sufficient strength, and now the fracture of a cranked axle rarely occurs.

The two chief improvements in the locomotive engine, which succeeded those now explained, and which brought that machine to its present state of efficiency, consisted, first, in the substitution of brass for copper tubes ; and, secondly, in the addition of another pair of wheels to support the engine. It was found, by continued experience, that the copper tubes, from some peculiar action of the fire upon them, which has never been explained or understood, were subject to rapid decay ; and in the year 1833, after an experience of about three years of the working of these engines, it occurred to Mr. Dixon, then one of the superintendents of the engineering department of the Liverpool and Manchester railway, to try the effect of brass tubes. The experiment was eminently successful; they were found to last six or eight times as long as copper tubes of the same dimensions. Having now brought down the history of the locomotive engine to the present time, we shall give a description of one of these machines in its most improved form.

Description of the most improved Locomotive Engine in operation in 1840.—A longitudinal vertical section of a locomotive engine is represented here.



The boiler, as has been explained in the engines already described, is a cylinder placed upon its side; the fire-box consists of two castings of metal, one within the other, bolted together by rivets represented at *k*; the fire-grate is represented at D. The fire door is represented at *g*, opening upon the platform where the engineer stands. It will be perceived in the section that the fire-box is on every side surrounded by the water contained between the two casings, the level of the water in the boiler being above the roof of the fire-box. The tubes by which the flame, and the products of combustion, are drawn from the fire-box into the smoke-box are represented at E. The smoke-box, containing the cylinders and the blast pipe, and supporting the chimney, is represented at F. In the engine from which the drawing was taken, the boiler is a cylinder of 7¼ feet long and 3¼ in diameter; it is clothed with a boarding of wood, represented at *a*, and bound round by iron hoops screwed together at the bottom. Wood being a slow conductor of heat, this covering has the effect of keeping the boiler warm, and checking the condensation of steam.

As the top of the fire-box would be liable to be destroyed by the action of the fire, if the level of the water in the boiler were suffered to fall below it, so as to leave it uncovered, a leaden plug is inserted in it, which would melt out before the copper would become injuriously heated, and the steam rushing out at the aperture would cause the fire to be extinguished. The tubes E, which serve to conduct the flame through the boiler to the smoke-box, are made of the best rolled brass, 1-13th of an inch thick, and 1⅝ of an inch in external diameter; they are 124 in number, and the distance between tube and tube is three-quarters of an inch. The number of these tubes is at present seldom less than 90, and varies between that and 150. The tubes act as stays, connecting the ends of the boiler to strengthen them; but, besides these, there are rods of wrought-iron, which extend from end to end of the boiler, above the roof of the fire-box. The smoke-box F, containing the cylinders, steam-pipe, and blast-pipe, is 4 feet wide, and 2 feet long; it is formed of wrought-iron plates, rivetted in the same manner as those of the fire-box. From the top of the smoke-box, which, like the fire-box, is semi-cylindrical, rises the chimney G, 15 inches diameter, made of ⅛-inch iron plates, rivetted and bound round by hoops. Near the bottom of the smoke-box the working cylinders are placed side by side, in a horizontal position, with the slide valves upwards.

At the top of the external fire-box, a circular aperture is formed 15 inches in diameter; and upon this aperture is placed the steam-dome T, 2 feet in height, and secured to the aperture by nuts. The steam-dome is made of brass, nearly half an inch thick. A funnel-shaped tube *d*, with its wide end upwards, is flanged upon the side of the great steam-pipe S, and is carried upward, so that its mouth is near the top of the steam-dome T. In order to pass into the steam-pipe S, the steam which fills the upper part of the boiler A must ascend the steam-dome and enter the funnel *d*, as indicated by the bent arrow. This arrangement prevents, in a great degree, the effect of priming, by which word is expressed, technically, the spray of water which rises from the water of the boiler, and is mixed with the steam in the upper part of it; as the steam ascends the steam-dome, this spray falls back, and nothing but pure steam enters the funnel *d*. The wider part of the great steam-pipe S is flanged, and screwed at the hinder end to a corresponding aperture in the back of the fire-box, where the engineer stands; this opening is covered by a circular plate, secured by screws, having a stuffing-box in its centre, of the same kind as is used for the piston rods of steam cylinders. Through this stuffing-box the spindle or rod *a* of the regulator passes; and to its end is attached a winch *h*, by which the spindle *a* is capable of being turned. To the other end of this spindle, at *e*, is attached a plate, which moves upon apertures formed in the cover of the end of the great steam-pipe S; so that, by turning the winch *h* more or less, this plate *e* may be removed more or less from the openings; and thus the steam may be allowed to inter the steam-pipe from the steam-dome in greater or less quantity, or may be shut off altogether. The steam-pipe S being inclosed within the boiler, is maintained at the same temperature as the steam in the boiler; and therefore the steam, in passing through it, is not liable to condensation. The steam-pipe, passing through the tube plate at the front of the boiler, is turned down at right-angles in the smoke-box, where, dividing into two branches, one is conducted to each of the valve-boxes of the cylinders. The lower ends of these branches are flanged to the valve boxes at the ends of the cylinders nearest to the boiler; by these pipes the steam is conducted into the valve-boxes, or steam-chests, from which it is admitted by slide-valves to the cylinders to work the pistons. On the upper sides of the cylinders are the steam-chests U, communicating with the passage; *m*, fig. 5, leading to the top of the cylinder, *n* leading to the bottom, and *o* leading through the side-pipe to the P′ blast-pipe. These openings are governed by a slide, so that, when steam is admitted through *m*, the communication shall be opened between *n* and *o*. Thus, when steam is admitted to the top of the cylinder, the steam from the bottom will flow from *n* through *o*, into the blast-pipe. When the piston reaches the bottom of the cylinder, then the slide opens a communication between *n* and the steam-pipe, and between *m* and *o*. Thus steam will be admitted to the bottom of the cylinder, while the steam from the top will escape from *m*, through *o* to the blast-pipe. In this way, by the alternate shifting of the slide, steam is admitted alternately to each end of the cylinder, and allowed to escape from the other end, and the alternate motion of the piston and the cylinder is thereby maintained. The pistons used in locomotive engines are of the kind called metallic pistons, and, from their horizontal position, they have a tendency to wear unequally in the cylinders, their weight pressing them on one side only; but from their small magnitude, this effect is found to be imperceptible in practice. The cross pipe P′, which communicates with the eduction passage *o*, in each of the valve-boxes, has an opening in the centre, presented upward. To this opening is flanged the base of the blast pipe *p*, fig. 4, which rises in a direction slightly curved, and has its mouth presented upward in the centre of the chimney G. The steam which is discharged at each stroke of the pistons from the cylinders, passes through this pipe, and escapes up the chimney by puffs. When an engine is moving slowly, these puffs are distinctly audible, resembling the coughing of a horse; but when at full speed, they succeed each other so rapidly that the ear can scarcely distinguish their intervals. It is this stream of waste steam, continually rushing up the chimney, that maintains the necessary draught in the fire-place; the upper current thus produced in the funnel causes a corresponding current into the smoke-box F, through the tubes E; and there is this excellence in the arrangement, that the force of the draught in the chimney being proportional to the quantity of steam produced, it must be therefore proportional to the quantity of fuel necessary to be consumed.

The force of the steam thus impressed upon the pistons is communicated by the piston rods Y, the cross heads of which move in guides to the connecting rods B, which are attached to the crank pins of the working axle C; so that, as the piston rods are driven backwards and forwards in the cylinders, the working axle is made to revolve. As this axle is the instrument by which the impelling force is conveyed to the load, and as it has to support a great portion of the weight of the engine, it is constructed with great strength and precision. Its length is 6¼ feet, and its diameter 5 inches. At the centre part it is cylindrical, and is increased to 5¼ inches, where the cranks are formed. The sides of the cranks are four inches thick; and the crank pins, which are truly cylindrical, are 5 inches in diameter and 3 in length. Upon the parts which are 7¼ inches long, the great driving wheels D are firmly fastened, so as to be prevented from turning or shaking upon the axle. Brasses are fixed on the outside of the engine, which rest upon these projections G of the axle; and upon these brasses the weight of the engine is supported.

The strength and accuracy of construction necessary for these axles render them expensive; they cost almost $200 each. They are seldom broken, but sometimes bent when the engine escapes from the rails.

The method by which the slides are made to govern the admission and escape of the steam to and from the cylinders, is nearly the same as in the steam-engine used for the general purposes of manufacture; and for a general description of the method see STEAM-ENGINE. Meanwhile it may be here briefly stated, that this is effected by two circular plates called eccentrics, on the great working axle. These eccentrics are circular plates or rings, formed upon or attached to the axle so as to revolve in their own plane, forming, in effect, a part of the axle itself; but they are so placed that their centres do not coincide with the centre of the axle, and, consequently, as they revolve with the axle, their centres are alternately thrown backwards and forwards, as they pass on the one side or the other of the axle. These circular plates are surrounded by rings, within which they revolve, but which do not revolve with them. These rings are alternately thrown backward and forward by the play of the eccentrics; and to these rings are attached rods *e e*, which communicate motion to the arms which drive the rods of the slides. Thus the alternate motions of the eccentrics backward and forward proceeding from the working axle, produce a corresponding backward and forward motion in the slides, and thereby govern the admission and escape of the steam to and from the cylinders. When it is required to reverse the motion of the engine, or to make it move backwards, the motion of the slides, and therefore the positions of the eccentrics on the working axle, must be the contrary of that necessary to produce a progressive motion. Sometimes this is effected by shifting the position of the eccentrics on the working axle; but more commonly it is effected by a second pair of eccentrics, first placed on the axle in a position contrary to the others. When the engine is driven backward, the eccentrics are thrown out of gear, and the other eccentrics are brought into action.

As all the moving parts of the engine require to be constantly lubricated with oil, to diminish the friction and keep them cool, oil cups for this purpose are fixed upon them. In some engines these oil cups are attached separately to all the moving parts; in others they are placed near each other in a row on the side of the boiler, and communicate by small tubes with the several parts to be lubricated.

The tender is a carriage attached behind the engine, and close to it, carrying coke for the supply of the furnace, and a tank containing water for the boiler. The feed for the boiler is conducted through a curved pipe proceeding from the tank and carried first downwards, and afterwards in a horizontal direction, as represented at K, under the boiler. It communicates with a forcing pump, which is worked by an arm driven by the cross head of the steam piston. By this pump water is constantly forced into the boiler, so long as the pump is kept in communication with the tank; but this communication may be opened and cut off by a cock *l*, governed by the engineer. As the feed of the boiler by the introduction of cold water checks the activity of the evaporation, it is the custom not to feed the boiler regularly and constantly, but to throw on the feed when the work on the engine is light and the consumption of steam small, and to shut it off when much steam is required. The circumstances of a railway naturally suggest this. When the engine is ascending an incline, all the steam which the boiler is capable of producing is required, and therefore the activity of the boiler is stimulated by shutting off the feed; but in descending an incline less power is required, and the feed is put on.

Until within the last few years, locomotive engines were supported on only four wheels. It is now, however, the general practice to place them on six, the driving wheels being in the middle. To give greater security to the position of the engine between the rails, it is usual to construct flanges on the tires of all the six wheels. Mr. Stevenson, however, has been in the practice of constructing the driving wheels without flanges, and with tires truly cylindrical, depending on the flanges of the two pairs of smaller wheels to maintain the engine between the rails. The wheels of the engine are constructed in this manner. The driving wheels D are fixed on the cranked axle C, and are constructed with cylindrical tires without flanges. They are 5 feet in diameter. The wheels L are 3 feet 6 in. in diameter, and have conical tires with flanges. They are placed immediately behind the smoke-box. The wheels M are precisely similar to L, and are placed immediately behind the fire-box.

When an engine is required for the

transport of very heavy loads, such as those of merchandise, the adhesion of one pair of working wheels is sufficient; and, in such cases, one of the two pairs of wheels L or M is made of the same diameter as the driving wheels, and a bar is attached to points on the outside of the wheels, at equal distances from their centre, connecting them in such a manner that any force applied to make one pair of wheels, revolve must necessarily impart the same motion to the other pair. By such means the force of the steam is made to drive both pairs of wheels, and consequently a proportionally increased adhesion is obtained.

The speed which an engine is capable of imparting depends on the rate at which the pistons are capable of being moved in the cylinders. By every motion of each piston backward and forward one revolution of the driving-wheel is produced: and by each revolution of the driving-wheels supposing them not to slip upon the rails, the load is driven through a distance equal to their circumference. As the two cylinders work together, it follows that a quantity of steam sufficient to fill four cylinders must be supplied by the boiler to the engine, to move the train through a distance equal to the circumference of the driving-wheels; and in accomplishing this, each piston must move twice from end to end of the cylinder, each cylinder must be twice filled with steam from the boiler, and that steam must be twice discharged from the blast-pipe into the chimney. If the driving-wheels be 5 feet in diameter, their circumference will be 15 feet 7 inches. To drive a train with a velocity of 30 miles an hour, it is necessary that the engine be propelled through 45 feet per second; and to accomplish this with 4 feet wheels they must make nearly 3 revolutions per second; and as each revolution requires two motions of the piston in the cylinder, it follows that each piston must move three times forward and three times backward in the cylinder in a second; that steam must be admitted six times per second to each cylinder, and discharged 12 times per second through the blast-pipe: the motion of the slides and other reciprocating parts of the machinery must consequently correspond.

This rapid reciprocating motion being injurious to the machinery, attempts have been made to diminish it by the adoption of larger working-wheels, and the driving-wheels on several of the great lines have been accordingly increased to 5½ and 6 feet in diameter. Such engines have not been yet sufficiently long in use to afford a practical estimate of the effects of this change. Experiments of a much bolder kind have been tried in England on the Great Western Railroad, where driving-wheels of 10 feet in diameter have been worked. From a course of experiments, however, made by Dr. Lardner with those engines, it did not appear that they had any advantage over those constructed with smaller and lighter wheels. Experience appears to have since confirmed this, as they are now for the most part abandoned. The pressure of steam in the boiler is usually limited by two safety-valves—one represented at N, under the control of the engineer; and the other at O, which cannot be approached by him. The safety-valve at N is held down by a lever *r*, which is attached to a spiral spring, and which may, by an adjusting screw, be made to press on the valve with any required force. The second valve O is pressed by several small elliptical springs, placed one above another over the valve, and held down by a screw, which turns in a frame fixed into the valve seat. By this screw the pressure on the valve can be adjusted.

In order to give notice of the approach of the train, a steam-whistle Z is placed immediately above the fire-box at the back of the engine. This is an apparatus composed of two small hemispheres of brass, separated one from the other by a small space. Steam is made to pass through a hollow space formed in the lower hemisphere, and escapes from a very narrow circular opening round the edge of that hemisphere. The edge of the upper hemisphere presented downwards encounters this steam, and an effect is produced similar to the action of air in organ pipes. A shrill whistle is produced, which can be heard at a great distance, and differing from all ordinary sounds, never fails to give notice of the approach of a train.

It is not usual to express the power of locomotives, in the same manner as that of other engines, by the term *horse power*. Indeed, until the actual amount of resistance encountered by these machines shall be more certainly ascertained, it is impossible that their efficiency can be estimated. The quantity of water evaporated supplies a major limit to the power exerted; but even this necessary element is not ascertained. Mr. Stevenson states that an engine such as that above described is capable of evaporating only 77 cubic feet of water per hour; but Dr. Lardner found that the mean evaporation obtained by a very accurately conducted experiment over 200 miles of railway, with an engine called the "Hecla," similar to the above, was 90 cubic feet per hour very nearly.

But a still greater evaporating power than this is found among the large engines working on the Great Western Railway. In an experiment made by Dr. Lardner with the "North Star," drawing 110½ tons gross, at 30½ miles an hour, the evaporation was 200 cubic feet an hour.

On the evaporating power of the engines, other things being the same, must ultimately depend the speed of railway traffic. For it must be apparent that no modification which can be made in the mechanism of the engine, no change in the magnitude of the driving-wheels, nor any other expedient of the same kind, can add any thing to the real working power of the machine. Mechanism is the means by which power is modified and conveyed to the working points, not the agent by which it is produced. The real and the only source of power in the steam-engine is to be found in the phenomena which are evolved in the conversion of water into vapor (for an account of which phenomena see **Steam**); and therefore the limit of railway speed must always depend on the rate at which the locomotive boiler is capable of evaporating water. The experiments above explained show the actual evaporating powers possessed by the boilers now in use, and every addition to such evaporating power will produce a corresponding, though not a proportionate, augmentation of the speed of railway trains.

Nothing can be more absurdly exaggerated than the accounts which have been put in circulation of the speed attained on railways. No reliance whatever can or ought to be placed on such reports, unless they are attested by competent persons accustomed to that kind of inquiry, and who have been themselves witnesses of them. In the extensive courses of experiments which, for several years back, have been conducted by Dr. Lardner, he has never in any instance, even with an unloaded engine, exceeded a speed of 45 miles an hour; nor was that speed ever maintained for any considerable distance. With the best and most powerful engines on the Great Western Railway at their disposal, Mr. Nicholas Wood and Dr. Lardner were unable to attain a speed in their experiments exceeding 45 miles an hour. The question, however, of most interest to the public is, not the speed which can be obtained in experiments for short distances, with engines put into racing order, but the average speed which can be maintained in the general working of a road. The returns of the railway companies, so far as they have been made public, do not supply the means of determining this; but it is known that the first class trains between London and Birmingham, a distance of 112 miles, could not until within the last few years make the journey, under ordinary circumstances, in less than 5½ hours; this would give an average speed, including stoppages, of 20 miles an hour. On the Grand Junction line between Liverpool and Birmingham, the journey, including stoppages, was usually made in 4¾ hours, and the distance is 97 miles; this again is at the rate of about 20 miles an hour.

The quickest journey on record was made August 28, 1848, on the Great Western Railway, England, by the "Courier" locomotive, which ran with an express train weighing 60 tons, from Didcot to Paddington, a distance of 53 miles, in 49 minutes 13 seconds, or at the rate of 67 miles an hour. The average speed on railways, in this country, varies from 25 to 33 miles per hour.

A new engine has been placed upon the Boston & Worcester Railroad, manufactured by Mr. Ross Winans, of Baltimore, which has some peculiarities about it. It is made for burning anthracite coal, and has a fire-box 6 feet in length, 3½ in width, and about 2 feet in depth, which will contain at least a ton of coal. The fire grate is composed of stout, separate bars, so arranged as to permit the firemen to turn them and shake out the ashes, even when the doors of the fire-box are closed.

It is 28 tons weight, with two driving-wheels, 7 feet in diameter, and 8 supporting or truck-wheels—the driving-wheels being in the centre. It is made so that the adhesive power or weight may be thrown upon the driving-wheels, for the purpose of ascending steep grades, and thus adhesive power can be concentrated or spread over the whole of the wheels, according as it is needed. We understand that for a short distance it attained the speed of 60 miles per hour.

LOCOMOTIVE POWER, in contradistinction to stationary power, is any kind of moving power applied to the transport of loads on land which travels with the load which it draws. Horses employed to draw carriages or carry loads are locomotive powers.

LOG. A machine used to measure the rate of a ship's velocity through the water. It is a piece of thin board, forming the quadrant of a circle of about six inches radius, and balanced by a small plate of lead, nailed on the circular part, so as to swim perpendicularly in the water, with the greater part immersed. The log-line is fastened to the log by means of two legs, one of which is knotted, through a hole at one corner, while the other is attached to a pin, fixed in a hole at the other corner, so as to draw out occasionally. The log-line, being divided into certain spaces, which are in proportion to an equal number of geographical miles, as a half or quarter minute is to an hour of time, is wound about a reel. The whole is employed to measure the ship's headway, in the following manner:—The reel being held by one man, and the half-minute glass by another, the mate of the watch fixes the pin, and throws the log over the stern, which, swimming perpendicularly, feels an immediate resistance, and is considered as fixed, the line being slackened over the stern, to prevent the pin coming out. The knots are measured from a mark on the line, at the distance of 12 or 15 fathoms from the log. The glass is, therefore, turned at the instant that the mark passes over the stern; and, as soon as the sand in the glass has run out, the line is stopped. If the glass runs 30 seconds, the distance between the knots should be 50 feet. When it runs more or less, it should, therefore, be corrected by the following analogy: As 30 is to 50, so is the number of seconds of the glass to the distance between the knots upon the line.

LOG-BOARD. Two boards shutting together like a book, and divided into several columns, containing the hours of the day and night, the direction of the winds, and the course of the ship, with all the material occurrences that happen during the 24 hours, or from noon to noon, together with the latitude by observation. From this table, the officers work the ship's way, and compile their journals.

LOG-BOOK, is a book into which the contents of the log-board is daily transcribed at noon, together with every circumstance, deserving notice, that may happen to the ship, or within her cognizance, either at sea or in a harbor, &c. The intermediate divisions or watches of a log-book contain four hours each.

LODE, is the name given by the Cornish miners to a vein, whether it be filled with metallic or earthy matter.

LOGWOOD, is the wood of the *Hæmatoxylon Campechianum*, a native tree of Central America, grown in Jamaica since 1715. It was first introduced into England in the reign of Elizabeth, but as it afforded to the unskilful dyers of her time a fugitive color, it was not only prohibited from being used, under severe penalties, but was ordered to be burned wherever found, by a law passed in the 23d year of her reign. The same prejudice existed, and the same law was enacted against indigo. At length, after a century of absurd prohibition, these two most valuable tinctorial matters, by which all our hats, and the greater part of our woollen cloths, are dyed, were allowed to be used.

Old wood, with black bark and with little of the white alburnum, is preferred. Logwood is denser than water, very hard, of a fine compact grain, and almost indestructible by the atmospheric elements; it has a sweet and astringent taste, and a peculiar not inoffensive smell.

When chipped logwood is for some time exposed to the air, it loses a portion of its dying power. Its decoction absorbs the oxygen of the atmosphere, and then acquires the property of precipitating with gelatine, which it had not before. The dry extract of logwood, made from an old decoction, affords only a fugitive color. Alcohol extracts most of the active principles of this wood, and forms a deep colored tincture. The tincture of the fresh wood is an excellent test for the presence of bicarbonate of lime in mineral waters, with which it produced a well marked violet colored solution.

LOOMS, are machines for crossing and weaving threads. The two materials are the warp and the weft, crossed and matted by a shuttle carrying the weft. There are various forms for different fabrics and materials, and next to the plough the loom is the most useful of machines. Until a few years they were uniformly worked by hand. See Cotton Manufacture, Silk, Flax, and Weaving, for a description of various kinds of looms.

Mr Joseph Reynolds, of Providence, R. I., has invented and received a patent for an improvement in looms for weaving shawls of different patterns, ginghams, also carpets and any kind of pattern goods. The improvement is one which should receive attention especially from those who manufacture fancy checked (tartan) shawls—a kind of fabric which has now become common to every nation in the world, many beautiful samples of which are now manufactured in America, and which are greatly to be improved, as designed by Mr. Reynolds. The patent of Mr. Reynolds states that "the object and advantage of his improvement over all other plans in use, for changing the shuttle, is, that his plan has full control of a series of shuttle boxes applied, either to one or both ends of the lay, as may be required, and that *pattern* plates are used to be set to any pattern which may be designed in stripes; or, if connected with a Jacquard, the improvement can be most judiciously employed, to the weaving of carpets with any kind of figures made of different colors of the weft." The pattern plates are set according to the design of the pattern to be woven, and by their combination with levers and bell cranks to the shuttle boxes, each shuttle is moved, or kept in its proper place, to be moved when required to work out the design of a four, five, or more different colors in different shuttles. For example, if five shuttles are used, and the middle one is red weft, while the two others on each side may be blue, green, orange and purple, the shuttles can be changed, as set by the pattern plates, to take up the red shuttle or any other one, of the five, either the middle one, or passing over from end to end of the whole set. The shuttles can also be set to vary in their operation from a few inches to yards, such as wearing the border of a shawl with a few picks of one, and more of another color, making stripes in the weft, then the loom will weave the whole middle of the shawl, without a change of weft, to have it all one color, after which the shuttles come into play to work out the opposite border. To work out patterns of this kind, a long, troublesome, and expensive pattern chain is employed, in looms at present in use; this is obviated by the pattern plates of Mr. Reynolds, which occupy but a small space in a snug box. An operative can attend two looms, owing to the loom not requiring to be stopped to change any shuttle. We have seen a sample of goods woven by this loom—a shawl of a good fabric and well woven. A loom is in operation in Providence.

LUBRICATION. The oiling of the joints and bearings of machinery to diminish friction. Resin, oil, and lard oil are substances which form the basis of the best lubricators. The best instrument (there are many forms) for using these lubricating liquids, is a tin cup with a tube passing downwards from its bottom, through which a cotton wick runs. The oil streams along this in a current suitable for application.

LUTES are pasty, or loamy and fatty matters, used to keep the joints of chemical and other apparatus subjected to heat tight. They differ according to the nature of the vessel and operation. *Linseed meal* made into a paste with water, closes very well the joinings of glass vessels. Milk, lime-water, and solution of glue, make this a better cement.

Glue, lime, and white of egg, mixed together, form a good cement for china and stoneware.

Cheese and lime also form a lute for similar purposes.

Linseed, pipe-clay, and melted caoutchouc form a good lute for acid vapors, and is always soft.

Fresh fire-clay and ground fire-bricks mixed together, form a cement for crucibles which have to stand a high degree of heat. *Willis lute* is 1 oz. of borax in a pint of hot water, with slaked lime for a paste: to be spread with a brush, with a finish of slaked lime and linseed oil. *Iron lute* is 1 part of sulphur, 2 of sal-ammoniac, and 80 of iron, rammed into joints. *Cup cement* is 5 parts of resin, 1 of beeswax, 1 of red ochre. *Soft cement* is yellow wax and one half of turpentine, with venetian red. The most common luting is made by rubbing in a mortar fine clay and linseed oil, for heat; or one of pipe-clay and three of fine sand well kneaded: beeswax melted with one eighth of turpentine does for cold operations. Glass vessels which are truly ground can do without luting, and may be covered with thin leather or sheet caoutchouc which is impermeable and scarcely acted upon by vapors.

LYCOPODIUM or Puff Ball. A cryptogamous plant, whose seeds ripen in September: they are used in theatres to imitate flashes of lightning, by being thrown across the flame of a candle, when they burst and scintillate.

MACARONI is a dough made of the flour of superfine wheat made into a pipe form, as thick as a goose-quill. It was first prepared in Italy, and introduced into commerce under the name of Genoese paste. The wheat is ground into a coarse flour, called *gruan* or *semoule* by the French, under light millstones placed somewhat apart. The dough is made from this *semoule*. *See* Vermicelli.

MACE is the *arillus* or thick tough covering of the shell of the fruit of the nutmeg (*myristica moschata*). It is of a brown or orange color. It is first dipped in brine, and then sun-dried. It has a more agreeable flavor than nutmeg, and has a pungent taste. It contains two kinds of oil, one unctuous, bland and thick; the other aromatic and volatile. The oil is used in medicine, and the membrane itself in cookery.

MACERATION is the pouring on of a quantity of cold water upon a substance, and leaving it to stand. The temperature does not exceed 65° Fahr.

Maceration is immersion in cold water or spirits. Digestion in hot. Infusion is in hot liquid. Decoction is continued heat or boiling. Extract is the evaporation of the water from an infusion or decoction.

MACHINE, in a general sense, signifies any thing which serves to increase or regulate the effect of a given force. Machines are either *simple* or *compound*. The simple machines, otherwise called the *simple mechanical powers*, are usually reckoned six in number; namely, the *lever*, the *wheel and axle*, the *pulley*, the *wedge*, the *screw*, and the *funicular machine*. See the respective terms.

Compound machines are formed by combining two or more simple machines. They are classed under different denominations, according to forces by which they are put in motion, as *hydraulic* machines, *pneumatic* machines, *electrical* machines, &c.; or the purposes they are intended to serve, as *military* machines, *architectural* machines, &c.

Although there are no limits to the combination and adaptations of machinery, there are certain general principles which may be applied in estimating the effects of any machine whatever. When a machine attains its state of uniform motion, the momentum of the power is equal to that of the resistance, and is the same that would be *in equilibrio* with the resistance if there were no motion at all. From this principle, and from the consideration that in all machines the work done is to be estimated not merely from the quantity of resistance which is overcome, but from the quantity overcome in a given time, we can ascertain the relation that ought to subsist between the velocity and the load or resistance, in order that the effect of the machine may be a maximum. This maximum effect is produced when the two following conditions are fulfilled: 1. When the load or resistance is about four ninths of that which the power, when fully exerted, is just able to balance, or that which would keep the machine at rest altogether; and, 2, when the velocity of that part of the machine to which the power is applied is one third of the greatest velocity of the power. These conditions are deduced from the following empirical expression, which is adopted by Euler and other writers to represent the law of the moving power: Let P=the power applied (or weight which the power, when fully exerted, is just able to overcome); R=the resistance, or load, or weight to be overcome; *c* the greatest velocity, or that at which the power ceases to act; *v*=any other velocity: then the law of the moving power is

$$R=P\left(1-\frac{v}{c}\right)$$

the variables in this expression are R and *v*, and the effect is represented by the product R *v*; on making which a maximum, the rules of the differential calculus give $v=\frac{1}{3}c$; whence the formula becomes R=4-9ths P.

From these expressions it follows, that when the moving power and the resistance are both given, if a machine be so constructed that the velocity of the part to which the power is applied is to the velocity of the part to which the resistance is applied in the ratio of 9 R to 4 P, the effect of the machine will be a maximum, or it will work to the greatest possible advantage. The above conditions apply equally to machines impelled by animal force and the agents of nature, as running water, steam, the force of gravity, &c. An animal exerts itself to the greatest advantage, or performs the greatest quantity of work in the least time, when it moves with about one third of the utmost speed with which it is capable of moving, and is loaded with four ninths of the greatest load which it is capable of putting in motion. It has been supposed in the above remarks that the friction of the parts of the machine is included in the resistance.

MACHINERY. The utility of machinery consists in the addition which it makes to human power. The forces derived from wind, water, and steam, are so many additions to human power, and the total inanimate force thus obtained in Great Britain has been calculated by Dupin to be equal te 20,000,000 laborers. Instead of working himself, man makes nature work for him, and, in that degree, ought to be enabled to live as well, and work less himself. The effect ought, in this respect, to ease the whole community, or it ceases to be an advantage. On the contrivance of every new tool, human labor is abridged. The man who contrived rollers quintupled his power over brute matter. A tool is usually a more simple machine, and generally used by the hand; a machine is a complex tool, a collection of tools, and frequently put in action by inanimate force. All machines are intended either to produce power, or merely to transmit power and execute work. All the mechanical powers are, in effect, levers.

In the *wheel* and *axle*, the wheel is the long arm, the axle the short arm, and their ratio or division is the power.

In the *pulley*, one gives no power, but two gives double the velocity of the power; three treble, and so on, exactly on the lever principle.

The *inclined plane* operates as a lever, because the distance moved on the plane is greater than the height gained; hence, the power is as the length of the plane to the height.

The *wedge* is another lever, on the same principle as the inclined plane, but varied in power by resistance.

The *screw* is a lever in which the power moves through the entire circumference, while the obstacle moves only through the distance of the threads.

Friction diminishes the results, but, in general, a fourth or fifth more power is applied than the calculation demands, to compensate for friction, and other causes of loss of power.

When two bodies balance each other by means of any machine, and are then made to move, the product of each into its velocity, *i. e.* the quantities of motion or momentum ascending or descending perpendicularly will be equal.

The quantity of power in motion is the velocity multiplied into the quantity of matter or number of atoms. Thus, a cubic inch of lead, moving 1 yard per second, has a momentum of 1; and 2 cubic inches a momentum of 2; or 1, moved 2 yards, a momentum of 2. But a cubic inch of stone, but half the density of lead, would, in yard per second, have but half the momentum of the lead, and two cubic inches of such stone must move twice as fast as the lead, to have the same force or momentum.

Hence, universally, velocity, bulk, and density, must be multiplied together for momentum; and, if we diminish one, we must increase one of the two others, or both, to have the same momentum. Animal, or other force, often stands for bulk and density, and then these must be varied as velocity.

As we increase velocity, with the same power we increase momentum; and, as we decrease velocity, we must increase power, to get an equal momentum.

This is the foundation of all mechanical science and practice, however varied or complicated; and this principle being understood, we may, by the aid of common arithmetic, be able to pursue every useful mechanical object.

It sometimes happens, as in chemistry, that the power is invisible; but, in these cases, if there is power, it is not the less matter and motion. Invisible atoms are concentrating, or are dispersing, or are moving one among another in such cases. We often understand their action, and sometimes do not; but our ignorance, in particular cases, creates no alteration in the general laws of nature.

To determine the relative velocity of a body moving in any angle from the direction of the moving force, multiply the velocity conferred by the moving force by the natural cosine of the angle, and the product is the velocity in the angular direction. And, to find the perpendicular distance of the two lines, multiply the angular velocity by the sine of the angular deflection, and the product is that distance. The relative lengths of the three lines is the measure of the force in each.

In cases of double or more forces, if lines are drawn from one another to represent all the forces at their angles, the resultant force is the line which completes the figure.

When the work to be done requires more force for its execution than can be generated in the time necessary for its completion, recourse must be had to a fly-wheel, which is a wheel having a heavy rim, so that the greater part of the weight is near the circumference. Another method consists in raising a weight, and then allowing it to fall. And another in condensing air, by great force, and then using its expansive force as required.

Uniformity in the motion of machinery is essential. The governor, in the steam-engine, and a vane or fly of little weight, but large surface, which revolves rapidly, and soon acquires a uniform rate by the resistance of the air, are contrivances for steadying power.

Increase of velocity is effected by a band, passing round a large wheel, and then round a small spindle.

Diminution of velocity is effected by systems of pulleys, or by transmission through a number of wheels.

Spreading the action of a force exerted for a few minutes over a large time, is one of the most useful employments of machinery, and the half minute which we spend in winding up a watch, is an exertion of force which, by the aid of *a few wheels*, is spread over 24 hours.

Machinery affords a sure means of remedying the inattention of human agents, by instruments; for instance, for counting the strokes of an engine, or the number of coins struck in a press. The *tell-tale*, a piece of mechanism connected with a clock, in an apartment to which a watchman has not access, reveals whether he has neglected, at any hour, to pull a string in token of his vigilance.

The precision with which all operations are executed by machinery, and the exact similarity of the articles made, produce economy in the consumption of all raw materials.

The accuracy with which machinery executes its work is, perhaps, one of its most important advantages. It would hardly be possible for a very skilful workman, with files and polishing substances, to form a perfect cylinder out of a piece of steel; but this process, by the aid of the lathe and the sliding-rest, is the every-day employment of hundreds of workmen.

The objections to machinery arise from the faulty distribution of its benefits to society, and the neglect and injustice of not fairly indemnifying those whose skill and capital is destroyed by new inventions.

Machinery is, therefore, in the production of cheap manufactures for exportation, and even for home consumption, to be regarded as a public benefit. But there are two parties, in regard to the advantages and disadvantages of machinery. The political economists, who consider society in the abstract, and look to general results, are partisans of all means which produce at the least cost, and, therefore, of machinery. So, also, inventors, or their assignees, who manufacture cheap, and, for a time, sell at the established price, or with such small abatement of the manual price as secures the market, thereby making vast profits. But the working artisan, who, by a machine, is thrown out of an employment by which he and his forefathers have long subsisted, and other manufacturers, who find themselves undersold and their trade destroyed, are enemies of all new machinery. The one is unable to learn a new trade, or to excel in it in the maturity or decline of life, and has no reserved capital, on which to subsist in the intermediate period; and the other, having embarked his capital in peculiar connections, finds it difficult, and even impossible, to withdraw it and establish any new and profitable business—so that the first are generally reduced to pauperism, and the latter to bankruptcy. It is with each an individual—a personal affair, for which there is no compensation in the general benefit arising to the community, or in the aggrandizement of the inventor. Nevertheless, the community do benefit immediately and remotely, and it is, therefore, contended, that the community are thereby qualified to indemnify the immediate sufferers, and that laws and arrangements ought to be made, so as to effect this just and desirable purpose. This would reconcile the conflicting interests; inventions would then be more numerous and better encouraged, and a fair and reasonable compensation from the public stock would reconcile all parties to the progress and inventions of machinery.

MADDER (Rubia), a genus of plants including an extensive family, of which the *galium* or bedstraw is one which closely resembles it in many properties. Fifteen species of it are known, but only one is indigenous in the United States—the *R. Brownii*, which grows in Florida, Georgia, and Jamaica. R. Tinctoria is the most important, on account of the fine scarlet color imparted by its roots, and, it is so essential to calico printers, that they could not carry on their business without it. Holland grows it very largely, and importations of it from there occur in every civilized country. France though it grows some, yet imports more from the Levant. From its great consumption here, it has become an object to introduce its growth and cultivation into this country, and successful efforts have been made by spirited individuals. The value of madder imported into this country is considerable, and if the article is well prepared, there seems no reason to doubt that it would find a ready market. Madder was successfully introduced into France one hundred years since, by Jean Althen, a Persian, to whom a statue is to be erected. This plant, it is said, now returns to France nearly 25,000,000 francs, or $5,000,000 per annum. The amount of the madder crop varies greatly one year with another, and it is difficult to give the mean crop. A hectare it is said, in a well manured ground and in favorable circumstances of temperature, will produce 5,000 killogrammes of dry roots, while in unfavorable circumstances it will not yield more than one-half or one-fourth of this amount. A kilogramme is equal to 2 lb. 2 oz. From the commencement of the present century, the greatest crops are stated not to exceed 25,000 quintals by measure, and the least about 10,000 to 12,000.

The average amount per annum of madder imported into this country, as appears by returns procured at the Treasury Department, from 1845 to 1847, is about 6,110,000 pounds, and in value, about $600,000. The value given is believed, however, to be too low, as it falls below the usual wholesale market price, one-quarter if not one-half.

Mr. Joseph Swift, of Buckingham, Ohio, is probably the most extensive cultivator of madder in the Union. His first crop was harvested in the fall of 1842, after being allowed four seasons' growth, and produced at the rate of 2000 pounds per acre.

The amount of labor required, including the preparation of land, planting, cultivating, digging, cleaning, threshing, &c., was from eighty to one hundred days' work per acre (including team work). The outlay for buildings, fixtures, &c., did not exceed, in all, fifty dollars.

The value of the crop was at the rate of fifteen cents per pound, at which price he sold most of it, notwithstanding the circumstance of its being unknown to purchasers, and having to encounter the prejudice that usually exists in such cases.

The result, then, in figures, fairly stated, stands thus, for an acre of good land properly managed:

By 2000 pounds of madder, at 15 cents per pound,		$300 00
Contra—To 100 days' work at 75 cents per day,	$75 00	
Use of land 4 years at $4 per year,	16 00	
Grinding, packing, &c.	9 00	
		100 00
Leaving a net profit per acre of..		$200 00

The *quality* of this madder was pronounced superior to most of the imported; and no difficulty was found in selling it wherever it became known. The price of madder in the western cities (and also at the east,) has varied during the past five years, from 14 to 18 cents per pound; the better qualities often selling at 18 to 20 cents, at wholesale.

The *yield per acre.* Mr. S. is now convinced, can be increased to 3000 lbs.; and it is better to harvest the crop at the end of three years' growth, than to allow a longer period. This plan will of course nearly double the profits.

Madder has been grown successfully by Mr. Gilm, a resident of Long Island. The crop does not require much attention. For the first year, it must be well wed and hoed lightly in summer; in the second year, hoeing in spring, summer, and fall; third year, the same repeated, and earthing up the roots of the plants,—at the close of the third year the crop may be harvested: after this, if left in the ground, it loses its strength. The roots are then largest and fullest of coloring matter. To raise them, a trench is dug round the roots, the earth loosened, and the whole roots of one plant raised together; these often weigh 40 lbs.: this diminishes by drying, to three-fourths of its weight. Sometimes madder is grown by setting out the roots. Twenty thousand plants are allotted to an acre. Roots the size of a quill are esteemed most, or not bigger than the little finger. After being picked it must be dried previous to grinding and preservation. In hot climates air-drying is used; stoves are used in Holland. The madder from Holland is most esteemed, and it is cultivated in that country to a great extent. In powder, it is of an orange-brown color, but is liable to become damp, and to be spoiled, if kept in a moist place.

Madder is used for dyeing woollen, silk, and also cotton goods, and the color is very lasting, and resists the action of the air and sun. Within a few years, a method has been discovered of rendering the red exceedingly brilliant and approaching to purple. It also forms a tint for several other shades of color: it has the curious properties of tinging the bones red of those animals which feed upon the roots.

It appears that madder may be considered as composed of two coloring substances, one of which is dun (tawny), and the other is red. Both of these substances may combine with the stuff. It is of consequence, however, to fix only the red part. The dun portion appears to be more soluble, but its fixity on stuffs may possibly be increased by the affinity which it has for the red portion.

The different additions made to madder, and the multiplied processes to which it is sometimes exposed, have probably this separation for their chief object.

The red portion of madder is soluble, but in small quantity, in water. Hence but a limited concentration can be given to its solution. If the portion of this substance be too much increased, so far from obtaining a greater effect, we merely augment the proportion of the dun part, which is the more soluble of the two.

In consequence of the Société Industrielle of Mulhausen having offered in the year 1826 large premiums to the authors of the best analytical investigation of madder, eight memoirs were transmitted to it in the year 1827. They were examined with the greatest care by a committee consisting of able scientific and practical men. None of the competitors however fulfilled the conditions of the programme issued by the society; but four of them received a tribute of esteem and gratitude from it; MM. Robiquet and Colin at Paris, Kuhlmann at Lille, and Houton-Libillardière. Fresh premiums were offered for next year, to the amount of 2000 francs.

Every real discovery made concerning this precious root, would be of vast consequence to dyers and calico-printers. Both M. Kuhlmann, and Robiquet and Colin, conceived that they had discovered a new principle in madder, to which they gave the name *alizarine*. The latter two chemists treated the powdered madder with sulphuric acid, taking care to let it heat as little as possible. By this action the whole is carbonized, except perhaps the red matter. The charcoal this obtained is pulverized, mixed with water, thrown upon a filter, and well washed in the cold. It is next dried, ground, and diffused through fifty parts of water, containing six parts of alum. This mixture is then boiled for one quarter of an hour, and thrown upon a filter cloth while boiling hot. The residuum is once more treated with a little warm alum water. The two liquors are to be mixed, and one part of sulphuric acid poured into them; when they are allowed to cool with occasional agitation. Flocks now make their appearance; the clear liquid is decanted, and the grounds are thrown upon a filter. The precipitate is to be washed, first with acidulated water, then with pure water, and dried, when the coloring matter is obtained in a red or purple state. This purple substance, when heated dry, gives out alizarine, and an empyreumatic oil, having an odor of animal matter; while a charcoally matter remains.

M. Dan. Koechlin, the justly celebrated calico printer of Mulhausen, has no faith in alizarine as the dyeing principle of madder; and thinks moreover that, were it of value, it could not be extracted on the great scale, on account of the destructive heat which would result from the acid acting upon a considerable body of the ground madder. Their alizarine is not a uniform substance, as it ought to be, if a proximate principle; for samples of it obtained in different repetitions of the process have produced very variable effects in dyeing. The madders of Avignon, though richer in color than those of Alsace, afford however little or no alizarine. In fact, *purpurine*, the crude substance from which they profess to extract alizarine, is a richer dye than this *pure* substance itself.

Madder contains so beautiful and so fast a color, that it has become of almost universal employment in dyeing; but that color is accompanied with so many other substances which mask and degrade it, that it can be brought out and fixed only after a series of operations more or less difficult and precarious. This dye is besides so little soluble, that much of it is thrown away in the dye-house; the portion supposed to be exhausted being often as rich as other fresh madder; hence it would be a most valuable improvement in this elegant art to insulate this tinctorial body, and make it a new product of manufacture.

According to Wolff and A. Strecker the composition of these two substances is,

Alizarine..........	$C^{20}H^{6}O^{6}$
Purpurine	$C^{18}H^{6}O^{6}$

Purpurine furnishes, like alizarine, all the colors produced by madder. It may be separated from alizarine by a boiling solution of alum, in which it dissolves: with potash it gives a currant red solution, while alizarine gives a blue by reflected, and a purple by transmitted light. Both are converted by nitric-acids into phtalic and oxalic acids. When madder is fermented by yeast only purpurine can be detected. The alizarine being converted into that substance with the evolution of carbonic acid and hydrogen. Schunck has demonstrated the presence of a bitter substance called by him rubian: it is not a coloring matter itself, but is in some way connected with the production of the coloring principles. It is a hard, dry, brittle, shining substance, like gum soluble in water and alchohol. When acted on by sulphuric and hydrodoric acids the products of the decomposition are: -1, alizarine; 2, verantine; 3, rubiretine; 4, rubianine. Schunck believes that alizarine and verantine form with alumina a compound soluble in boiling water, which is identical with purpurine.

It is a curious fact that madder grown on ground deficient in lime will not give much coloring matter, but when the ground has been well limed an abundance of red coloring matter is produced.

By digesting powdered madder in water, and acting upon the jelly like solution thus obtained, by boiling alcohol, an extract is afforded, which, at a subliming heat, yields the proper red coloring matter, or alizarine. Or ground madder may be treated directly with boiling alcohol; and to the solution dilute sulphuric acid is added, which precipitates the alizarine in a copious orange precipitate. Another principle, *xanthine*, is obtained from a fawn-yellow matter, soluble in alcohol and water, by precipitation with oxide of lead, washing the precipitate with alcohol, and extracting the color with sulphuric acid. It has an orange green tint, and a saccharine taste. It is believed that xanthine prevails in the rose colored tints of madder, and is absent in the violet.

The red mordants are prepared commonly in Alsace, as follows:—The crushed alum and acetate of lead being weighed, the former is put into a deep tub, and dissolved by adding a proper quantity of hot water, when about one tenth of its weight of soda crystals is introduced to saturate the excess of acid in the alum. The acetate of lead is now mixed in; and as this salt dissolves very quickly, the reaction takes place almost instantly. Care must be taken to stir it for an hour. The vessel should not be covered, lest its contents should cool too slowly.

Much mordant should not be prepared at once, for sooner or later it will deposit some sub-acetate of alumina. This decomposition takes place even in corked vials in the cold; and the precipitate does not readily dissolve again in acetic acid. All practical men know that certain aluminous mordants are decomposed by heating them, and restored on cooling. Gay Lussac observed, that by adding to pure acetate of alumina, some alum or sulphate of potash, the mixture acquires the property of forming a precipitate with a heat approaching the boiling point, and of re-dissolving on cooling. The precipitate is alumina nearly pure, according to M. Gay Lussac; but, by M. Kœchlin's more recent researches, it is shown to be sub-sulphate of alumina, containing eight times as much base as the neutral sulphate.

Madder dye.—On account of the feeble solubility of its coloring matter in water, we cannot dye with its decoction; but we must boil the dye-stuff along with the goods to be dyed; whereby the water dissolves fresh portions of the dye, and imparts it in succession to the textile fibres. In dyeing with madder, we must endeavor to fix as little of the dun matter as possible upon the cloth.

Dyeing on wool.—Alumed wool takes, in the madder bath, a red color, which is not so bright as cochineal red, but it is faster; and as it is far cheaper, it is much used in England to dye soldiers' cloth. A mordant of alum and tartar is employed; the bath of madder, at the rate of from 8 to 16 ounces for the pound of cloth, is heated to such a degree that we can just hold our hand in it, and the goods are then dyed by the wince, without heating the bath more till the coloring matter be fixed. Vitalis prescribes as a mordant, one fourth of alum, and one sixteenth of tartar; and for dyeing, one third of madder, with the addition of a 24th of solution of tin diluted with its weight of water. He raises the temperature in the space of an hour to 200°, and afterwards he boils for 3 or 4 minutes; a circumstance which is believed to contribute to the fixation of the color. The bath, after dyeing, appears much loaded with yellow matter, because this has less affinity for the alum mordant than the red. Sometimes a little archil is added to the madder, to give the dye a pink tinge; but this is fugitive.

Silk is seldom dyed with madder, because cochineal affords brighter tints.

Dyeing on cotton and linen.—The most brilliant and fastest madder red is the Turkey or Adrianople. The common madder reds are given in the following way:—The yarn or cloth is boiled in a weak alkaline bath, washed dried and galled, by steeping the cotton in a decoction of bruised galls or of sumach. After drying, it is twice alumed; for which purpose, for every four parts of the goods, one part of the alum is taken, mixed with 1-16th of its weight of chalk. The goods are dipped into a warm solution of the alum, wrung out, dried, and alumed afresh, with half the quantity. The acetate of alumina mordant, described above, answers much better than common alum for cotton. After the goods are dried and rinsed, they are passed through the dye-bath, which is formed of ¾ lb. of good madder for every pound of cotton; and it is raised to the boiling point by degrees, in the space of 50 or 60 minutes. Whenever the ebullition has continued a few minutes, the goods must be removed, washed slightly, and dyed a second time in the same way, with as much madder. They are then washed and passed through a warm soap bath, which removes the dun coloring matter.

Holterhoff prescribes for ordinary madder red the following proportions:—20 pounds of cotton yarn; 14 pounds of Dutch madder; 8 pounds of nut-galls; 5 pounds of alum; to which ¼ pound of acetate of lead has been first added, and then a quarter of a pound of chalk.

In the calico print-works the madder goods are passed through a bran bath first, immediately after dyeing; next, after several days exposure to the air, when the dun dye has become oxidized, and is more easily removed. An addition of chalk, on the principles explained above, is sometimes useful in the madder bath. If bran be added to the madder bath, the color becomes much lighter, and of an agreeable shade. Sometimes bran-water is added to the madder bath, instead of bran.

The ordinary madder-red dye is given in the following way:—The yarn, or cloth, is put into a very weak alkaline bath, at the boiling temperature, then washed, dried, and galled; or, when the calico is to be printed, for this bath may be substituted one of cow-dung, subsequent exposure to the air for a day or two, and immersion in very dilute sulphuric acid. In this way the stuff becomes opened, and takes and retains the color better. After the galling, the goods are dried, and alumed twice; then dried, rinsed, and passed through the madder-bath. This is composed of three-fourths of a pound of good madder for every pound weight of the goods. The bath is slowly raised to the boiling point in the course of 50 or 60 minutes, more or less, according to the shade of color wished for. When the boiling has continued for a few minutes, the stuff is taken out, washed slightly, and dried a second time in the same manner, and with as much madder. It is then washed and dried, or passed through a hot soap-bath, which carries off the fawn-colored particles. Other dyes, likewise, are added to the madder-bath, to obtain other shades of color; for instance, a decoction of fustic, weld, log-wood, quercitron, knoppern, the mordants being modified accordingly.

Holterhoff prescribes, for ordinary madder-red, the following proportions: 20 lbs. of cotton-yarn, 14 lbs. of Dutch madder, 8 lbs. of gall-nuts, 5 lbs. of alum; to which are added, first 1¼ lb. of acetate of lead, and, subsequently, ¼ lb. of chalk. When bran is added to the madder-bath, the color becomes much lighter, and of a more agreeable tint.—Adrianople madder-red is given by many distinct operations. The first consists in cleansing or scouring the goods by alkaline baths, after which they are steeped in oily liquors, brought to a creamy state by a little carbonate of soda solution. Infusion of sheeps'-dung is often used as an intermediate, or secondary steep. The operation of oiling, with much manual labor, and then removing the superfluous or loosely-adhering oil, with an alkaline bath, is repeated two or three times, taking care to dry hard after each process. Then follows the galling, aluming, maddering, and brightening, for removing the dun-colored principle, by boiling at an elevated temperature, with alkaline liquids and soap. The whole is often concluded with a rosing by salt of tin.

According to the latest improvement of the French dyers, each of the four processes of oiling, mordanting, dyeing, and brightening differs, in some respects, from the above.

1. Their first step is boiling the cloth for four hours, in water containing one pound of soap for every four pieces. Their saponaceous bath of a creamy aspect is used at a temperature of 75° F.; and it is applied by the padding machine 6 times, with the grassing and drying alterations. In winter, when the goods cannot be exposed on the grass, no less than 12 alternations of the saponaceous or white bath are employed, and 8 in spring. They consider the action of the sunbeams to aid greatly in brightening this dye; but at midsummer, if it be continued more than 4 hours, the scarlet color produced begins to be impaired.

They conceive that the oiling operation impregnates the fibres with supermargarate of potash or soda, insoluble salts which attack and condense the alumina, and the red coloring particles of the madder, so firmly that they can resist the clearing boil.

2. Their second step, the mordanting, consists first in padding the pieces through a decoction of galls mixed with a solution of equal weight of alum; and after drying in the hot flue, &c., again padding them in a solution of an acetate

of alumina, made by decomposing a solution of 16 lbs. of alum with 16 lbs. of acetate of lead, for 6 pieces of cloth, each 32 *aunes* long.

3. The maddering is given at two successive operations; with 4 pounds of Avignon madder per piece at each time.

4. The *brightening* is performed by a 12 hours' boil in water with soda crystals, soap, and salt of tin; and the *rosing* by a 10 hours' boil with soap and salt of tin. Occasionally, the goods are passed through a weak solution of chloride of potash. When the red has too much of a crimson cast, the pieces are exposed for two days on the grass, which gives them a bright scarlet tint.

MAGNESIA. A white, tasteless, earthy substance, usually obtained by exposing its hydrated carbonate to a red heat. Its specific gravity is 2·3. It is almost insoluble; but when moistened and put upon turmeric paper it reddens it: this sometimes depends upon a trace of lime. It is an oxide of a brilliant white metal, which has been called *magnesium*, and which may be obtained by heating chloride of magnesium with potassium: they act intensely upon each other, chloride of potassium is formed, and magnesium separates: it may be washed with water and dried. Heated to redness in the air, it burns with great brilliancy into magnesia, 12 parts of the metal combining with 8 of oxygen to form 20 of magnesia. In commerce, pure magnesia is generally distinguished by the term *calcined magnesia*; and the hydrated carbonate of magnesia, obtained by precipitating a solution of sulphate of magnesia by carbonate of soda, and washing and drying the precipitate, goes by the name of *magnesia*, or *magnesia alba*. The chief use of magnesia and its carbonate is in medicine. *Sulphate of magnesia* is obtained by evaporating the residue of sea-water after the common salt has been separated, or by adding sulphuric acid to *bittern* and evaporating, so as to obtain the resulting sulphate of magnesia. This salt is also obtained by the action of dilute sulphuric acid on magnesian limestone, and it is not uncommon in mineral waters: it was formerly procured from certain springs near Epsom, in Surrey, and was hence termed *Epsom salt*. It crystallizes in four-sided prisms with dihedral summits. Its crystals are soluble in their weight of water at 60°, and in three-fourths their weight at 212°. They melt when heated, and gradually lose their water of crystallization. They consist of 20 magnesia, 40 sulphuric acid, and 63 water. This salt is a useful purgative in medicine, and is the chief source of the other forms of magnesia. All the magnesian salts have a peculiar bitterish flavor. Magnesia is found native in the state of hydrate and carbonate; it exists as a compound part of several minerals, and many of them are soft or soapy to the touch.

The *carbonate of magnesia* may be made thus:—

Dissolve four parts of sulphate of magnesia, and three parts of subcarbonate of potash, separately, in twice their weight of water, and filter them. Then mix them with eight times their weight of boiling water. Boil and stir, and then stand till partly cool; when, being strained through linen, the carbonate remains. Wash it and dry it gradually. It is the best anti-acid in the stomach, and the acid renders it purgative.

It is however liable to produce accumulations in the bowels. Almost all the Epsom salts used in the United States is manufactured at Baltimore from the magnesite and magnesian limestone found in Lancaster county, Pa. The annual amount manufactured there is about 1,500,000 lbs.

Hydrate of Magnesia or *native* Magnesia is found at Hoboken, N. J., in thin seams traversing serpentine. The *Siliceous hydrate* is found in serpentine at Middlefield, Mass., and at Baltimore, Md. A variety of carbonate containing 4 per cent. of silex is called by the Germans Meerschaum, or Ecume de mer by the French. This is also found at Hoboken. Sulphate of magnesia in fine silky needles is found in caves in Kentucky, and efflorescing in the earth in Tennessee.

MAGNESIAN LIMESTONE. An extensive series of beds lying in geological position immediately above the coal measures; so called because the *limestone*, which is the principal member of the series, contains *magnesia*.

It is composed of carbonate of magnesia 46·5, carbonate of lime 52, with 1 of iron and manganese. *Or*, magnesia 20·3, lime 29·5, combined with 47·2 of carbonic acid, and 1 of iron and alumine. Another variety is 36 carbonate of magnesia and 62 carbonate of lime. The introduction of magnesia into limestones has not yet been clearly explained.

Magnesian limestone is used chiefly for manufacturing the salts of magnesia from. It ought never be burned into lime to be used as dressing on land; for the magnesia remains so long caustic in the ground that the roots of plants are injured and killed by it.

MAGNESITE. Native magnesia.

MAGNESIUM. The metallic base of magnesia; which see.

MAGNETIC COMPENSATOR. A contrivance devised by Mr. Barlow for eliminating the influence of a ship's guns and other iron in deranging the bearings of the compass. It consists of a plate or combination of plates of iron placed near the binnacle, so as to counteract, by an equal and opposite attraction, that of the rest of the iron on board the vessel. Mr. Airy has investigated the law of disturbance in the case of vessels built of iron, and shown that the disturbing force consists of a very large force of permanent magnetism in the rolled and hardened plates employed in the construction of the vessel, and a very small force of induced magnetism, which changes with the place of the ship, or rather with the varying circumstances of terrestrial magnetism by which it is produced. Mr. Airy has given a set of practical rules for correcting the disturbing forces by means of two powerful magnets placed at right angles to each other below the compass, and a box of small iron chain, which is used instead of Barlow's correcting plate..

MAGNET, NATURAL. One of the numerous oxides of iron; possessed, however, of properties peculiar to itself, if we except the metals nickel and cobalt, which possess it also in a very slight degree. The magnet consists chiefly of two oxides, together with a small portion of quartz and alumine. Its color varies in different specimens, according to minute differences in the ratios of the two oxides, and the nature of the foreign substances with which they are found united; but it is usually of a dark-gray hue, and has a dull metallic lustre. It is found in considerable masses in the iron mines of Sweden and Norway; in the Isle of Elba; in different parts of Arabia, China, Siam, and the Philippine Islands. Small magnets are also occasionally, though rarely, met with among the iron ores of this country. The properties are:

1. It attracts iron in all its states except the oxides.

2. If formed into a bar, and suspended freely by a hair, or on a pivot passing through its centre, it will turn itself round, and, after a few pendulous vibrations, settle into some one position; which it will retain if left undisturbed, or if disturbed will, after a few similar vibrations, return to it again as before.

3. By rubbing on a bar of steel it will give the bar the same properties; and a bar of soft iron will, while contiguous to it, even when not touched by it, obtain the same properties, which, however, the iron does not, like the steel, retain upon removal.

4. The position of rest is different at different places, and different at the same place at distant periods of time.

A great number of amusing toys have been formed of this substance, and the phenomena are often at first sight very surprising; but its application to the purposes of navigation renders it one of the most important discoveries ever made. The earlier navigators believed that it pointed always to the north pole of the world; and that, therefore, by means of it they could always at once tell the direction of their meridian, and consequently in what *direction* they were sailing. It was hence called the *loadstone*, or *leading stone*.

The employment of the loadstone itself for the purposes of navigation has long been laid aside; as *artificial magnets* can be constructed having a much greater intensity of directive power.

MAGNETIC NEEDLE. An instrument suspended by its centre, and magnetized, which shows the direction of the resultant of the magnetic forces at the place of observation.

MAGNETIC PYRITES. Native black sulphuret of iron; it attracts the magnetic needle.

MALTHA. Mineral pitch. It is nothing more than thickened petroleum or rock oil.

MANGANESE. This name is generally given to a black mineral, originally described in the year 1774, by Scheele, as a peculiar earth, and which was afterwards shown by Gahn to be the oxide of a metallic substance which he called *magnesium*. This term, however, having been applied to the metallic base of magnesia, the word *manganese* has been adopted to designate the metal, and the ore above alluded to has been called black, or peroxide of, manganese. The metal itself has a specific gravity of about 8. It is gray, hard, brittle, and very difficult of fusion, and has not been applied to any use. The black oxide, on the contrary, is largely employed as a source of oxygen, and is especially important from the use which is made of it in the decomposition of common salt for the production of chlorine. Manganese may be represented by the equivalent 28; and the black oxide, being a compound of 1 atom of manganese and 2 of oxygen, has the equivalent 44 (28 + 16). There is also a protoxide of manganese, composed of 28 metal + 8 oxygen, which is the basis of the salts of this metal. When hydrate or carbonate of potassa, or nitre, are fused with peroxide of manganese in an open vessel, a dark-colored compound is obtained, long known under the name of *chameleon mineral*, in consequence of its yielding in cold water a solution which is at first green, then blue, purple, red, brown, and ultimately deposits a brown powder, and becomes colorless. This substance has since been termed *manganate of potash*, and has been proved to contain a compound of 1 atom of manganese and 3 of oxygen, which has been called *manganic acid*, and is represented by the equivalent 52. In the pink solution, which is produced at once by the action of hot water, manganese exists in a still higher state of oxidizement, forming the *per-manganic acid*, in which 2 atoms of manganese are combined with 7 of oxygen. Both these compounds are very easy of decomposition. Some of the proto-salts of manganese have lately been used in calico-printing as the source of brown colors, and occasionally as deoxidizing agents.

The black oxide of manganese occurs abundantly in Vermont at Bennington and Monckton, accompanied with hæmatite. Black wad is only found in Connecticut. Phosphate of manganese is met with at Washington, Ct. Sulphuret of manganese is found in New-York.

Manganese is found native combined with iron, and when added artificially to steel it improves the quality. Gold and iron are rendered more fusible by its addition, and the iron becomes more ductile. Copper becomes whiter, less fusible, and more liable to tarnish. The most extensive use of oxide of manganese is in bleaching to produce chlorine, and it is often desirable to test the value of these ores.

M. Gay Lussac has proposed to determine the commercial value of manganese ore by the quantity of chlorine which it affords when treated with liquid muriatic acid. He places the manganese powder in a small retort or mattress, pours over it the acid, and the chlorine being disengaged with the aid of a gentle heat, is transmitted into a vessel containing milk of lime or potash water. This liquor is thereafter poured into a dilute solution of sulphate of indigo; and the quantity of chlorine is inferred from the quantity of the blue solution which is decolored.

This mode of testing is easily understood. When muriatic acid is acted on by manganese ore, the black oxide in it yields up one equivalent of its oxygen, and becomes reduced to the condition of protoxide of manganese: the atom of oxygen seizes on the equivalent of hydrogen in the muriatic acid, and sets the chlorine, the other element of the acid, free; and thus for every one atom of manganese present one atom of chlorine is liberated. If the amount of the latter is determined, it of course represents the weight of manganese.

The manufacturer of flint glass uses a small proportion of the black manganese ore, to correct the green tinge which his glass is apt to derive from the iron present in the sand he employs. To him it is of great consequence to get a native manganese containing as little iron oxide as possible; since in fact the color or limpidity of his product will depend altogether upon that circumstance.

Sulphate of manganese has been of late years introduced into calico-printing, to give a chocolate or bronze impression. It is easily formed by heating the black oxide, mixed with a little ground coal, with sulphuric acid. (*See* CALICO-PRINTING.)

The peroxide of manganese is used also in the formation of glass pastes, and in making the black enamel of pottery.

MANGLE is a machine for pressing heavy linen after washing. The linen, &c., is wrapped round rollers, and these are passed, backward and forward, under a heavily-loaded case. The best are those in which the winch turns but one way, the motion being reversed in the geer when the case has run home.

An improved mangle has been made by which linen may be both ironed and mangled at the same time. It is worked by a moving table, which passes under a pressure of 1½ ton; and the operation may be performed by a child of eight or nine years old. The machine does not occupy a space of more than eight superficial feet, and the weight of the whole is not more than 2 cwt. A good mangle is now made by three heavy rollers laid vertically: a winch handle works the intermediate one, and the upper is pressed down by a screw to any desired amount of pressure.

MANGO. A celebrated fruit, now produced in most of the tropical parts of the globe. The taste is delicious, slightly acid, and yields only to the mangosteen. It attains the height of 30 or 40 feet, has a rapid growth, and is very productive. The fruit is kidney-shaped, subject however to a good deal of variation in size, form, and color, and contains a large flattened stone. More than 80 varieties are cultivated, some of which are very beautiful, and diffuse a delightful perfume.

The mango has been fruited both in France and England. If a stove, or part of a stove, were fitted up for them, there can be no doubt but that the mango may be had on the table as easily as the pineapple.

MANGOSTEEN. A far-famed fruit, is the product of a middling-sized and beautiful tree, the *garcinia mangostana*, and was originally brought from the Molucca islands, but is now cultivated in many parts of the East Indies. It is, on all hands, admitted to be the most delicious, as well as the most wholesome, of all known fruits; it requires the same treatment as the mango. To these may be added the jambosteen, rambosteen, and deeku; they are natives of the Oriental Archipelago, and, when obtained, might be cultivated along with the preceding in the Southern States.

MANIHOT.—Two kinds are cultivated in the W. Indies, the sweet cassada of *Browne's Jamaica*, and *Manihot Aipi*, whose root is of a white color, and free from deleterious qualities. The bitter cassada, or manioc has a yellowish root, and abounds in a poisonous juice. By various processes, by bruising between stones, by a coarse rasp, or by a mill, the root of the manioc is broken into small pieces, then put into a sack, and subjected to a heavy pressure, by which all the juice is expressed. What remains is cassava, or cassada, which, if properly dried, is capable of being preserved for a great length of time. In French Guiana, according to Aublet, cassava flour is made by toasting the grated root over the fire, in which state, if kept from humidity, it will continue good for 20 years. Cassava-cake, or cassava-root, is the meal, or the grated, expressed, and dried root of the manioc, pounded in a mortar, passed through a coarse sieve, and baked on flat circular iron plates, fixed in a stove. The particles of meal are united by the heat; and, when thoroughly baked in this manner, from cakes, which are sold at the markets, and universally esteemed as wholesome kind of bread. The Spaniards, when they first discovered the West Indies, found this in general use among the native Indians, who called it cazabbi, and by whom it was preferred to every other kind of bread, on account of its easy digestion, the facility with which it was cultivated, and its prodigious increase. Again, in Guiana, cipipa is another preparation from this plant, and is the name given to a very fine and white fecula, which, according to Aublet, is derived from the expressed juice of the roots, which is decanted off, and suffered to rest for some time, when it deposits an amylaceous substance, which requires repeated washing.

The root of the manioc is also the basis of several kinds of fermented liquors; and an excellent condiment for seasoning meats, called cabion or capion, is prepared from the juice, and said to sharpen the appetite. The leaves, beaten and boiled, are eaten after the manner of spinach; and the fresh root is employed in healing ulcers. The expression of the juice from the root deprives the latter of all its deleterious properties; and that the application of heat to these juices renders their residue also wholesome and nourishing. And whilst cassava-bread is, as Sloane says, in the most general demand of any provision all over the West Indies, and is employed to victual ships, the use of tapioca is still more extended, and throughout Europe is employed for the same purposes as sago and arrow-root.

MANNA IN TEARS, is that which flows spontaneously from manna ash-trees, and dries upon the bark; mostly the fraxinus rotundifolia; but, in less quantity, by the F. ornus, F. excelsior, and F. parvifolia; also by the plum, oak, and willow.—*Flake Manna*, hangs in stalactites from straw, &c., bound round a tree in June and July. Manna is laxative, in a dose of 2 scrs. to ½ oz. for children or double for adults, in milk or any other liquid. *Common Manna* flows from incisions, made after the 1st of August, in Sicily.—*Briançon Manna* is found on the leaves of the larch, in Dauphiny.—*Arabian Manna*, the *Manna of Moses*, is exuded, in June, from a species of tamarisk, growing in the desert, and only collected at early dawn, as it melts in the heat of the day, and runs into the sand. It is white and solid, if kept cool, but melts by the heat of the hand. It is sweet, aromatic, and very scarce.—*Persian Manna* exudes from the Hedysarum alhagi, and is used as a purgative.

MANURES. Substances added to the soil, with a view of accelerating vegetation, and increasing the production of the crops. Animal, vegetable, and mineral substances are used for this purpose. Decomposing animal matter of any kind forms one of the most powerful manures, and in many instances accelerates the decay and decomposition of inert vegetable matters mixed with it; as in the mixture of dung and straw which forms the common offal of stables. All animal excrements are also powerful manures, and, when duly applied to the soil, soon exhibit their influence by the luxuriance of the crop. It, however, often happens, in respect to esculent vegetables, that their quality is deteriorated, and that they acquire a coarse and rank flavor if over-manured; as is the case with much of the produce of the market-gardens near large cities, where in consequence of the vicinity, manure is abundant, and luxuriant and fine-looking vegetables in great request for the table.

In all cases where animal manures are used, care should be taken that they are brought into action upon the soil as soon as they begin to decompose, or as soon as possible afterwards, and not suffered to rot, and exhale their best constituent parts while lying in the farm-yard. The drainings and the exhalations of a common dung-heap contain its most effective ingredients; and these are often suffered to go to waste, or to contaminate the air and collect in pools of filth. The fresh and the old manure of this decomposition are known to farmers under the terms *long* and *short* dung: the advantages and economy of the former, when properly applied, cannot be doubted. Those animal manures which are slow of decompositon are most durable, and generally most effective in their operation. Of these, the best is ground bones, the animal part of which is very gradually dissolved out by moisture; so that their effect is long-continued, and their earthy matter is also, probably, beneficial, at least to many crops. Vegetable manures are often very effective, especially as in the case of ploughing in a green crop, where all the soluble matters are brought into action; and inert vegetable substances may be rendered active by mixture with those which easily putrify, or with animal matter. Some vegetables, such as cabbages and many other cruciform plants, approximate to animal matter in their composition, and are proportionately good manures. Mineral manures act in two ways: either by their causticity, as is the case with quicklime, by which they decompose most organic bodies, such as roots, fibres, &c., and render them soluble and nutritious to the growing crop; or they alter the texture of the soil. Thus, sand may be called a manure for clayey lands, and clay and loam for those that are sandy. Upon the same principle, stiff soils are improved by paring and burning, by which a superficial sandiness is produced, and the texture of the soil rendered more appropriate for vegetation.

The principle on which manures act has only been fully understood since chemistry has lent its aid to agriculture. When crops grow upon soils they remove a certain portion of mineral matters, which, if not replaced, leave that ground deficient, and a constant course of cropping with one plant will remove nearly, if not all, the substances which the plant requires out of the soil. The crop will every year diminish, till ultimately it does not return its seed. Such is the case of Virginia with tobacco cultivation, and many parts of the south with cane culture. The ground so treated is not *perfectly* barren, for it will grow other crops; and if these be planted and removed without any addition to the ground, the latter becomes permanently sterile. This is the condition of much of the land in Europe, which is cultivated by those who have no real interest in the good of the soil; and it is the condition toward which much of the land of New England and the Atlantic States is approaching from ignorance and careless farming. Now, to restore those mineral substances, which have been removed by a crop or a rotation, is the object of manuring, and a manure ought always be looked upon as certain substances added for the supply of the wants of the crop. The soil does not require addition or improvement, except so far as it ministers to the wants of the plant. Hence the folly of using only one variety of manure for various kinds of crops. All plants do not require lime; hence constant liming is unnecessary, and constant farm manure, without other additions, is equally absurd. The manure should contain those things which the crop or the rotation requires. It should contain the exact chemical salts, and sufficient to supply the deficiency which the crop produces. To know what manures to apply, it is necessary to know what minerals plants abstract, and this is learned by a chemical analysis of the crop. There are now analyses made of most of the cultivated plants, from which data special manures may be deduced—the application of which is more certain and economical than the old fashioned mode. This subject of special manures is but in its infancy; and analyses of American plants, made by trustworthy chemists, are extensively required, until which be done little absolute exactitude can be obtained. It is in this line that a bureau of agriculture at Washington could act most efficiently. Plants do not remove more than 14 elements out of the soil, and, therefore, comparatively few substances are required to be added as manure. These are silica, lime, magnesia, oxide of iron, potash, soda, ammonia, sulphuric, phosphoric, and carbonic acids. To supply these in the cheapest and most effective forms is the object of the farmer. Silica always exists in ground in sufficient quantity. Lime is added either as caustic lime, or as compost with farm sweepings, or as marl, which is an impure carbonate, with a little phosphate and sulphate. *Gypsum* supplies lime with sulphuric acid, and *bones* or *phosphorite* supplies lime with phosphoric acid, as phosphate of lime. Guano also supplies phosphate of lime, but the chief object of guano is to supply ammonia by decomposition. The value of bones is much increased by acting on it with sulphuric acid, forming what is called dissolved bones. The use of bones and guano are the two greatest modern improvements in agriculture. Potash is absolutely required by some plants, as maize and oats, and may be added in the form of pearlash or nitre. Cow-dung contains salts of potash, and much of it depends upon the presence of the potash. Some plants prefer potash when they can have a selection, otherwise they appear to thrive just as well on soda. This fact of substitution is not fully understood in agriculture; in practice we do know that one substance will replace another in the plant without injury. This resembles isomorphism in minerals very much. Potash and soda have a remarkable effect in developing the leaf and other green parts of plants. The nitrates of potash and soda exert a wonderful influence in this way. It is not easy to say how much is due to the acid, and how much to the alkaline element. Unleached ashes is always preferable to the leached. Ammonia is the most powerful stimulant to all plants, and is required by them. The salts of ammonia are generally too expensive, and hence the use of those substances which supply it by decomposition. Animal matters, urine, excrement, wool, hair, horn, guano, and the gelatine in bones all act in this way, and that is the most efficient manure which decomposes most readily, and affords the ammonia most quickly. Night-soil is a most powerful manure, but it is disliked on account of its unpleasant odor—this, however, is gotten rid of by mixing it with fresh burned charcoal. *Fish*, along shore, forms a most valuable manure for corn or potatoes, and is fully equal to guano. *Sea-weed* is beneficial on account of the large quantity of saline matters which it adds to the ground.

MANUSCRIPTS. (Lat. manu scriptum, *written by the hand.*) Literally, writings of any kind, whether on paper or any other material, in contradistinction to such as are printed. Books were generally written upon vellum, after the papyrus used in classical times had become obsolete, until the general introduction of paper made from rags, about the 15th century after Christ; and the finest and whitest vellum is generally indicative of great age in a manuscript. The dearness of this material gave rise to the practice of using old manuscript books on which the writing had been erased, and also to that of abbreviations. These were carried to excess in the 12th century, and from that time until the invention of printing; and for a long period subsequent to that invention, abbreviations were still in common use: in Greek printing they were usual until within the last fifty years. Of Latin MSS., those prior to the reign of Charlemagne (A. D. 800) are considered ancient. Manuscripts of the early classical age were written on sheets rolled together. *Illuminated manuscripts* are such as are embellished with ornaments, drawings, emblematical figures, &c. illustrative of the text. This practice was introduced at a very early period; for we find the works of Varro, Pomponius, Atticus, and others, adorned by illuminations. But it was chiefly employed in the breviaries and prayer-books of the early Christian church. The colors most employed for this purpose were gold and azure. Illuminations were in a high state of perfection between the 5th and 10th centuries; after which they seem to have partaken of the barbarism of the middle ages, which threw their chilling influence over every description of art. On the revival of the arts in the 15th and 16th centuries many excellent performances were produced; but the art did not take deep root, and we believe the last specimen of illumination executed in England was Cardinal Wolsey's *Lectionary*, at Christ Church, Oxford.

MAP. (Lat. mappa.) A delineation of some portion of the surface of the sphere (terrestrial or celestial) on a plane. Terrestrial maps are *geographic* or *hydrographic*. A map representing a small extent of country is called a *topographical map*.

Terrestrial Maps.. The object of a terrestrial map is to exhibit the boundaries of countries and the relative positions of their several parts. A perfect representation of a country should present all its parts, not only in their true relative positions, but also in their just proportions. This may be accurately done on a globe; but as the earth's surface is spherical, it is impossible to represent any considerable portion of it on a plane so that the distances of places shall retain the same proportions which they have on the sphere, and geographers have accordingly had recourse to various methods of delineations, all of which have their peculiar advantages in particular cases.

One method is to represent the points and lines of the sphere according to the rules of perspective, or as they would appear to the eye, having some assigned position relatively to the sphere and the plane of representation. This method gives rise to the different modes of *projecting* the sphere, of which the three principal are the orthographic, the stereographic, and the central. The method of projection answers very well when the surface to be represented is small, and the eye is placed perpendicularly over it; but when it embraces a considerable portion of the sphere, the parts near the extremities of the map are much distorted.

A second method is to suppose the surface to be represented to be a portion of the surface of a cone, whose vertex is somewhere in the polar axis produced, and which either touches the sphere at the middle latitude of the surface to be represented, or falls within the sphere at the middle latitude, and without it at the extreme parallels. The conical surface is then supposed to be developed on a plane (which it admits of being); whence this method is called the method of development. Of this method there are various modifications: as that of Murdoch, who supposes the side of the cone to be parallel to the tangent of the meridian at the middle latitude, but to penetrate the surface of the sphere between the middle latitude and the extremities of the projected arc; that of De Lisle, who assumed the cone such as to intersect the sphere in the two parallels equally distant from the extreme and middle latitudes; that of Euler, who placed the apex of the cone at a determinate distance beyond the pole.

A third method is to lay down the points on the map according to some assumed mathematical law, the condition to be fulfilled being that the parts of the spherical surface to be represented, and their representations on the map, shall be similar in their small elements. Of such methods the best known is *Mercator's Chart* (which, however, may be produced also by development), in which the meridians are equidistant, parallel, straight lines, and the parallels of latitude are also straight lines perpendicular to the meridians; but of which the distances from each other increase in going from the equator in such a proportion as always to show the true bearings of places from one another.

Celestial Maps.—For the construction of his maps of the stars, the astronomer Flamstead adapted the following method: All the parallels on the sphere are represented by straight lines, and likewise one of the meridians; namely, that which passes through the middle of the map. The parallels which are all perpendicular to this meridian have the same relative lengths as on the sphere, and consequently the degrees of longitude are represented in their just proportions; that is, are proportional to the cosine of the latitude. If, therefore, the parallels be each divided into the same number of equal parts, a curve line drawn through the points of division will represent the meridians. By this method, any distance in the direction of the parallels is equal to the corresponding distance on the sphere; but it is evident that the map is much distorted towards the extremities, in consequence of the oblique directions of the meridians. Flamstead's method is sometimes used in geography for representing countries which lie on both sides of the equator, in which case the distortion is less. A modification of it, which consists in substituting arcs of circles for the straight lines representing the meridians, whereby their obliquity is diminished, is extensively employed in the construction of maps. The Society for the Diffusion of Useful Knowledge has adopted the gnomonic projection for laying down their maps of the stars.

MAPLE. A genus of plants, consisting of trees or arborescent shrubs. Twenty-seven species are known, of which 12 inhabit North America, 6 are found in Europe, 6 in Japan, and the remainder in Asia.

The sugar-maple (*A. saccharinum*) is one of the most valuable. It grows between Lat. 42° and 48° N. and flourishes in cold and moist situations: in all N. England, Western New York, Canada, L. Superior shores, and down the Alleghanies, it is met with. A variety with undulations, called *birds-eye* maple, is much used in furniture. The black sugar maple (*A. Nigrum*) is found in Ohio and farther South.

Besides the sugar which is obtained from the sap, the wood affords excellent fuel; and, from the ashes are procured four-fifths of the potash which forms such an important item of commerce. The sugar is superior in quality to the common brown sugar of the West Indies, and, when refined, equals the finest in beauty. A single tree of this species will yield 5 or 6 lbs. of sugar.

Sugar Maple, (*acer saccharinum*,) *Sycamore*, and *Norway Maple*.—The sap of these trees, as well as that of the common maple, is used for making sugar and wine. The wood of the European maple is employed in making violins.

MARANTA INDICA, is the plant whose roots yield Indian arrow-root.

MARBLES FOR TOYS. These well-known articles are made in great quantities, to serve in the games of children; some are formed of potter's clay, covered with a glaze, and burnt in a proper furnace; others are made of marble and alabaster, but chiefly of a species of very hard calcareous stone, found in the neighborhood of Cobourg, in Saxony. These stones are first broken into square blocks by means of a hammer, and are finally rounded into spheres or small balls by a mill. In order to this, they are placed, from 100 to 150 at a time, upon a fixed slab of stone, having a number of concentric circular grooves or furrows made in its flat surface. Above this stone, another flat slab, or block of oak, of the same diameter, is supported by means of a lever, and turned round by the power of the mill. During the rotatory action of this mill, small threads of water are made to enter each of the concentric grooves, which favor the rounding and polishing of the balls, and prevent the wood from heating. The operation of each of the quantities abovementioned lasts for a quarter of an hour, and the balls, or marbles, become perfectly spherical and fit for sale. Immense quantities of them are exported to India and China. A mill, with three turning-blocks, will manufacture 60,000 marbles a-week.

MARBLE. This title embraces such of the primitive, transition, and purer compact limestones of secondary formation, as may be quarried in solid blocks without fissures, and are susceptible of a fine polished surface. The finer the white, or more beautifully variegated the colors of the stone, the more valuable, *ceteris paribus*, is the marble. Its general characters are the following:—

Marble effervesces with acids; affords quicklime by calcination; has a conchoidal scaly fracture; is translucent only on the very edges; is easily scratched by the knife; has a spec. grav. of 2·7; admits of being sawn into slabs, and receives a brilliant polish. These qualities occur united in only three principal varieties of limestone; 1, in the saccharoid limestone, so called from its fine granular texture resembling that of loaf sugar, and which constitutes modern statuary marble, like that of Carrara; 2, in the foliated limestone, consisting of a multitude of small facets formed of little plates applied to one another in every possible direction, constituting the antique statuary marble, like that of Paros; 3, in many of the transition and carboniferous, or *encrinitic* limestones, subordinate to the coal formation.

The saccharoid and lamellar, or statuary marbles, belong entirely to primitive and transition districts. The greater part of the close-grained colored marbles belong also to the same geological localities; and become so rare in the secondary limestone formations, that immense tracts of these occur without a single bed sufficiently entire and compact to constitute a workable marble.

Marbles abound in the United States both fine-grained and coarse. The quarries in the neighborhood of Philadelphia afford a clouded handsome marble; at Thomastown, in Maine, a similar variety occurs. Of black marble, resembling the Irish lucullite, there is an extensive deposit at Shoreham, Vermont, which furnishes the chief supply to the States. The bed lies directly on the shores of L. Champlain, so that the blocks when lifted can be transported by water. Most of it goes to Middlebury to be polished. In the neighborhood of this last town a clouded granular marble is found: a dove-colored variety is quarried at Pittsford, Vt., as also at Great Barrington and Sheffield. The white marble of Conn. and Westchester, N. Y., are too coarse and granular for building purposes, besides having tremolite and other crystals scattered through them. Verd antique exists in Vermont and Conn.: that from the latter State being most beautiful. Variegated and shell marbles exist in the Western States; and a beautiful conglomerate (pudding stone) or breccia is found at the base of the Blue Ridge, Md., on the bank of the Potomac, 60 miles above Washington. The inner columns of the Capitol are made of it.

Of cutting and polishing marble.—The marble saw is a thin plate of soft iron, continually supplied, during its sawing motion, with water and the sharpest sand. The sawing of moderate pieces is performed by hand, but that of large slabs is most economically done by a proper mill.

The first substance used in the polishing process is the sharpest sand, which must be worked with till the surface becomes perfectly flat. Then a second, and even a third sand of increasing fineness is to be applied. The next substance is emery of progressive degrees of fineness, after which tripoli is employed; and the last polish is given with tin-putty. The body with which the sand is rubbed upon the marble, is usually a plate of iron; but for the subsequent process, a plate of lead is used with fine sand and emery. The polishing rubbers are coarse linen cloths, or bagging, wedged tight into an iron planing tool. In every step of the operation, a constant trickling supply of water is required.

MARGARIC ACID. The substance into which the margarine, or concrete portion of certain oils, is converted by the action of alkalies. It has a pearly lustre, and is insoluble in water: but readily soluble in hot alcohol, which deposites it as the solution cools. It fuses at 140°, and reddens litmus. It closely resembles stealic acid, but is more fusible.

MARGARINE. The solid, fatty matter of certain vegetable oils, has been thus termed by Lecanu, from its pearly lustre. The purest margarine is obtained from the concrete portion of olive oil.

MARGARITIC ACID. A distinctive term applied to one of the fatty acids which result from the saponification of castor oil. By the same process, this oil also yields the ricinic and the elaiodic acids.

MARGARONE. When margaric acid is mixed with quicklime and distilled, a peculiar fatty product, which crystallizes in pearly scales is obtained, which has been distinguished by the above term from other analagous substances.

MARGIN in Printing, is the arrangement of the pages in a sheet at proper distances from each other, according to the size of the paper; so that when the sheet is printed and folded, the border of white paper round them shall be regular and uniform in every leaf in the book.

MARGIN OF A COURSE. In Architecture, that part of the upper side of a course of slates which appears uncovered by the next superior course.

MARINE GLUE is made by mixing solutions of india rubber and shellac in coal-tar naptha, and evaporating the mixture: it is melted when required to be used.

MARL, is compact limestone and argillaceous matter, and essentially composed of carbonate of lime and clay, in various proportions. Marl frequently contains sand and other foreign ingredients. It occurs in masses, either compact, or possessing a slaty structure. All solid marl crumbles by exposure to the atmosphere, and it crumbles more easily, or forms a more tenacious paste, in proportion as it is more argillaceous. All marls effervesce with acids, sometimes very briskly and sometimes feebly, according to their solidity and the proportion of carbonate of lime, which may vary from 25 to 80 per cent. Earthy marl, like the indurated, may be either calcareous or argillaceous. It sometimes greatly resembles clay, but may be distinguished by its effervescence in acids. Marl is found associated with compact limestone, chalk, gypsum, or with sand or clay, and contains various organic remains, as shells, fish, bones of birds and of quadrupeds, and sometimes vegetables. Its most general use is as a manure, and whether a calcareous or an argillaceous marl will be more suitable to a given soil, may be determined by its tenacity or looseness, moisture or dryness.

Loam is sand and clay, *marl* is limestone and clay; and the more lime the better as manure, and the less the better for brick-making.

The composition of marl varies in proportion to its origin. Some of the marls in western New York are gypsum containing 20 per cent. of plaster. Almost all marls contain phosphate of lime, sometimes as much as 2 per cent. It is a valuable dressing for land, but it should be dug out and frosted previously to laying on.

MASSICOT. Yellow oxide of lead.

MAST. A long piece or system of pieces of timber, placed nearly perpendicular to the keel of a vessel to support the yards or gaffs on which the sails are extended. When the mast is one entire piece, it is called a *pole-mast*; but in all larger vessels it is composed of several lengths, called *lower*, *top*, and *top-gallant* mast: sometimes a fourth, called a *royal* mast.

The method of supporting each mast on the one next below it is peculiar. On the sides of the lower mast, some feet below the head, are placed cheeks: on these are fixed horizontally two short pieces of wood, fore and aft, called *trestle trees*. Across these at right angles are laid, before and abaft the mast, two or more longer and lighter pieces, called *cross trees*, which give the name to the entire system. On the mast head itself is a *cap*.

The topmast being placed up and down, the fore side of the lower mast is *swayed* up between the trestle trees, and through the round or foremast hole in the cap. When raised so high that the *heel* of the topmast is nearly up to the surface of the cross trees, a piece of iron, called the *fid*, is put through the hole in the heel for the purpose; and on this fid, of which the ends are supported on the trestle trees, the topmast rests. When fidded, the topmast is *stayed*, and the rigging or shroud *set up* to the *dead eyes* in the ends of the cross trees. These dead eyes pull from the lower rigging below, and thus the cross trees serve merely to extend the rigging. The topgallant is supported in the same manner on the topmast. When the mast is to be taken down, it is first raised to relieve the fid; which being drawn out, the mast is lowered.

The masts are supported by a strong rope, leading forward, called the *stay*; by others, leading aft on each side of the ship, called, in general, *backstays*; and by others abreast, called *shrouds*, and also *breast backstays*.

MASTIC. A cement used lately in building for plastering walls. It is made with a considerable portion of linseed oil and gets hard in a few days. It is used where expedition is required.

MASTIC. A resin obtained by making incisions in the *pistacia lentiscus* a small tree which grows in the Mediterranean shores: its berries yield oil and the wood is used medicinally. It is used only in varnishes. Among the Turks the women chew it to clean their teeth.

MATCHES, LUCIFER. The manufacture of these useful little articles constitutes a most extensive business. In some large factories the wood alone for the annual consumption approaches in value $5,000.

Lucifer matches are sulphur matches, to which a separate inflammable compound is afterwards added. The primary coating of sulphur cannot well be dispensed with, for the inflammable compound burns too rapidly to set fire to the wood. The flame produced by it is first transferred to the sulphur and then to the wood. The original matches were made by mixing phosphorus with mucilage at 104°, till it became a mucilage, to which chlorate of potash was then added. The sulphured wood was dipped in this. Sometimes the phosphorus was replaced by sulphuret of antimony. The noise of their inflaming was objectionable, and *noiseless* matches were then made by replacing the detonating action of chlorate of potash, for the slower combustion of nitrate and phosphorus. The general principle concerned in the action of all these matches is, that substances (as phosphorus), having a great affinity for oxygen, are mixed with a large amount of it, condensed into a small space (as in nitre or chlorate of potash), so that the slightest cause is sufficient to effect the combination. The peroxides of lead and manganese, which abound in oxygen, are often mixed with the nitre. They act in the same way when they have reached a red heat.

The wood is split by a perforated metallic plate having a steel face and strengthened by a bell-metal back. A convenient size for these plates is 6 inches × 3, and one inch thick. The wood is compressed laterally into the countersunk openings and forced through the holes, which are slightly countersunk to favor the entrance and separation of the wooden fibres. The materials into which the matches are dipped may be made either with or without sulphur. The latter kind have the following materials entering into their composition:

Phosphorus	4 parts
Nitre	10 parts
Fine Glue	6 parts
Red Ochre or Red Lead	5 parts
Smalt	2 parts

Melt the glue with water into a jelly,

and put it in a warm place to melt; melt the phosphorus in this at a heat of 140°, add the nitre, then the lead, and lastly the smalt, till the whole is a paste.

Melt a little white wax in a shallow vessel: char the ends of the wooden match and then dip them in the wax; shake them dry and then dip them in the paste. When dry they will kindle by friction.

The ordinary matches consist of nitre and chlorate of potash, sulphur, gum, and phosphorus, colored with the puce colored oxide of lead.

The *patent allumettes* are made of the first described paste, which is applied to the extremity of a thin wax bougie.

MATRIX. In Metallurgy, the stony substance in which crystalline minerals and metals are embedded is frequently termed their *matrix* or *gangue*. In dye-sinking the *matrix* is the indented mould from which impressions are taken in relief. Type-founders apply the term to the iron moulds in which the letters are cast.

MATTER. Substance. Of the intimate nature of matter the human faculties cannot take cognizance, nor can data be furnished, by observation or experiment, on which to found an investigation of it. All we know, or ever can know of matter, is its *sensible properties*. Some of these are the foundation of physical science; others, of the different subordinate sciences, as, for instance, of chemistry.

Matter is divisible by abrasion, and other means, into small fragments, which, when the division is carried to any considerable extent, are called particles. It is supposed, however, and many reasons appear to justify the hypothesis, that it is capable of reduction into particles (called atoms) of particular forms, and each class having its own proper magnitude and peculiar properties; that determinate numbers of atoms of one kind admit of combination with some determinate number of another kind, or of several kinds, and of thereby forming compounded atoms, having properties peculiar to that combination, and different from the *known* properties of their elemental atoms. These solutions and combinations result from properties inherent in the atoms themselves; but whether the simple classes of atoms that are believed to exist are themselves really primary and elemental is not known, and probably never can be with certainty.

In larger masses, or in masses of aggregated atoms, so classed that their peculiar properties are mutually neutralized, phenomena are exhibited which bear a great resemblance to one another through considerable classes of such compounds, whose elements we have reason to believe differ very considerably; and other properties are found to exist in all, and differing only in degree or intensity. These last are the subjects of *physical* investigation: they are called emphatically the properties of matter; and the laws of their mutual influences are the foundation of *mechanical philosophy*. These properties may be regarded as either essential or contingent. The essential properties of matter are usually reckoned the following:

1. *Divisibility*, or the property which every known substance possesses of being separable into parts, and these again into smaller parts, and so on until the parts become inappreciable to our senses; nor can any limit be placed on the subdivision.

2. *Impenetrability*, or a resistance exerted by every body to the occupation of its place by another. This resistance is of various degrees of intensity, dependent on the state and atomic composition of the bodies; but no two bodies can simultaneously occupy the same place.

3. *Porosity*, or the separation of the particles or atoms from each other by intervals or pores. Every substance with which we are acquainted is more or less porous.

4. *Compressibility*, or the property in virtue of which the volume of every body may be contracted into smaller dimensions.

Among the essential properties of matter may also be included *extension* and *figure*; but these belong also to space, and form the subject of geometry.

The contingent properties of matter are *mobility* and *weight*. Matter in every form is capable of being moved from one place to another; and every substance gravitates towards the centre of the earth. But motion has reference to space, and weight to the attraction of other matter.

The above are the general properties of matter, upon which physical investigations depend. There are, however, various other qualities belonging to particular substances, or to matter in particular states, the consideration of which is important in mechanical philosophy. Among these the principal are *elasticity*, *fluidity*, *hardness*, *rigidity*, *solidity*—for which see the respective terms.

MAUNDRIL. In Coal Mines, a pick with two shanks.

MEERSCHAUM: already alluded to under MAGNESIA. It consists, according to Klaproth, of silica, 41·5; magnesia, 18·25; water and carbonic acid, 39. Other analysts give, silica 50, magnesia 25, water 25. It occurs in veins or kidney-shaped nodules, among rocks of serpentine, at Egribos, in the island of Negropont, Eski-Schehir in Anatolia, Brussa at the foot of Mount Olympus, at Baldissero in Piedmont, in the serpentine veins of Cornwall, and at Hoboken, N. J.

When first dug up, it is soft, greasy, and lathers like soap; and is on that account used by the Tartars in washing their linen. The well-known Turkey tobacco-pipes are made from it, by a process analogous to that for making pottery ware. The bowls of the pipes, when imported into Germany, are prepared for sale by soaking them first in tallow, then in wax, and finally by polishing them with shave-grass.

MELLITIC ACID, which is associated with alumina in the mellite or honeystone, crystallizes in small colorless needles, is without smell, of a strongly acid taste, permanent in the air, soluble in water and alcohol, as also in boiling hot concentrated sulphuric acid, but is decomposed by hot nitric acid, and consists of 50·21 carbon, and 49·79 oxygen.

MENACHANITE. An ore of Titanium, found in England.

MERCATOR'S CHART, or PROJECTION. A representation of the sphere on a plane, in which the meridians are represented by equidistant parallel straight lines, and the parallels of latitude also by straight lines perpendicular to the meridians. This projection, which is universally adopted for nautical charts, by reason of the facilities which it affords in navigation from the circumstance that the rhumb, or sailing course beween two points, is represented by a straight line, was invented by Gerard Mercator (his true name was *Kauffman*, of which Mercator is the Latin equivalent), a native of Rupelmonde, in East Flanders, born in the year 1512. But, though Mercator gave his name to the projection, it does not appear that he knew the law according to which the distance of the parallels from the equator increases. The true principles of the construction were found by Edward Wright, of Caius College, Cambridge, who explained them in his treatise, entitled *The Correction of certain errors in Navigation*, published in 1599, and are as follows: Suppose one of the meridians on the globe to be divided into minutes of a degree; one of these, taken at any parallel of latitude, will be to a minute of longitude, taken on that parallel, as the radius of the equator to the radius of the parallel; that is, as radius to the cosine of the latitude, or as the secant of the latitude to radius. This proportion holds true on the map in this sense, that if a minute of the equator be taken as the unit of a scale, and that unit be considered as the radius of the tables, then the representation of a minute of latitude will be expressed by the number in the trigonometrical tables which is the secant of that latitude. Hence, in the map, while the degrees of longitude are all equal, the degrees of latitude marked on the meridian form a scale of which the distances go on increasing from the equator towards the poles, each being (approximately) the sum of the secants of all the minutes of latitude in the degree. The numbers resulting from the addition of the secants of the successive minutes, reckoned from the equator, form a scale of meridional parts, which is given in all books of navigation. The very remarkable property of this projection, namely, that the divisions of the meridian are analogous to the excesses of the logarithmic tangents of half the respective latitudes augmented by 45°, above the logarithm of the radius, was discovered by Bond about the year 1645; but was first demonstrated by James Gregory, in his *Exercitationes Mathematica*, published in 1668.

MERCURY. This metal is found chiefly in the state of *sulphuret*, which is decomposed by distillation with iron or lime. It is also found *native*. Mercury is the only metal which is liquid at common temperature; it is white and very brilliant. It freezes and assumes a crystalline texture at 40° below zero. Its specific gravity is 13·5. It boils at 660°, and its vapour condenses upon cool surfaces in minute brilliant globules. It is not altered by exposure to air at common temperatures, but when kept in vessels to which air has access, at a temperature near its boiling point, it gradually becomes converted into a deep red crystalline substance, which is the *peroxide*, or *red oxide, of mercury*. When mercury is dissolved in cold dilute nitric acid, the pure alkalis throw it down in the form of *black protoxide*. The same oxide is also obtained by triturating calomel with solution of caustic potash. These are the only definite oxides of mercury. The equivalent of this metal is about 200, and the oxides, consisting respectively of 1 atom of mercury and 1 of oxygen, and 1 and 2 are represented by 200+8=208, and 200+16=216. Mercury is represented in chemical formulæ by *Hg.*, from the Latin *hydrargyrum*, literally signifying *water silver*. The symbol of the protoxide will then be ($hg.+o.$), and of the peroxide ($hg.+2\,o.$). Each of these oxides combines with the acids, and produces the *protosalts* and *persalts* of mercury.

Mercury and Chlorine.—There are two *chlorides of mercury; a protochloride* or *calomel*, and a *perchloride* or *corrosive sublimate.* Calomel may be obtained by mixing 60 parts (1 equivalent) of common salt, or chloride of sodium, with 248 parts (1 equivalent) of protosulphate of mercury, and exposing the mixture in a proper subliming vessel to a red heat; the chlorine of the salt combines with the mercury of the sulphate to form protochloride of mercury (consisting of 200 mercury and 36 chlorine); and the sodium of the salt, uniting with the oxygen of the oxide of mercury, becomes soda, which, with the sulphuric acid, forms sulphate of soda. Calomel may also be obtained by mixing 200 parts of mercury with 272 of corrosive sublimate, and subliming the mixture. When thoroughly washed and levigated, calomel is a tasteless, white powder; its specific gravity is 7·2. When heated it acquires a yellow color; and at a temperature below redness it rises in dense white fumes, which are deposited in the form of a white powder upon cold surfaces. It is insoluble in water. When hastily sublimed it often becomes a crystalline horny mass, and occasionally forms beautiful prismatic crystals. It is sometimes found native; forming, however, a very rare ore, called, from its appearance, *horn quicksilver.*

Perchloride of mercury, or corrosive sublimate, is obtained by sublimation from a mixture of 120 parts of common salt (or 2 equivalents), and for 296 (or 1 equivalent) of persulphate of mercury. It rises in the form of a white crystalline substance, of an acrid metallic taste, highly poisonous, soluble in 20 parts of cold and in 2 of boiling water. Its specific gravity is 5·2. When heated it evaporates in acrid fumes, at a temperature below that required for the volatilization of calomel. Corrosive sublimate is a compound of 1 equivalent of mercury and 2 of chlorine. In the above process for preparing it, the chlorine is furnished by the chloride of sodium, and sulphate of soda is the other product.

Bisulphuret of Mercury, known also by the name of cinnabar or vermilion, is prepared artificially by heating together 100 parts of mercury with about 20 of sulphur; they form a black compound, which, when strongly heated, rises in the form of a deep crimson-colored sublimate; this, reduced by long trituration into a fine powder, acquires a brilliant red color. It is tasteless, and insoluble in water; it consists of 200 mercury and 32 sulphur, or ($hg.+2\,s.$) A black *protosulphuret of mercury* ($hg.+s.$) is precipitated by sulphuretted hydrogen from a solution of the protonitrate. When a mixture of equal weights of finely-powdered peroxide of mercury and Prussian blue is boiled in water till the blue color disappears, the solution yields, when filtered and evaporated, a crop of straw-colored prismatic crystals, which are *bicyanuret of mercury*: $2\,cy.+hg.$

Mercury is found in various parts of the world. Among the principal mines are those of Almaden, near Cordova, in Spain; Idria, in Carniola; Wolfstein and Morsfield, in the Palatinate; Guanca Velica, in Peru. It is stated by Dr. A. T. Thompson, in his *Dispensatory*, that most of the mercury used in England is brought from Germany. But, whatever may have been the case formerly, this is not certainly true at present. On the contrary, of 314,286 lbs. of quicksilver imported into England in 1831, none was brought from Germany: 269,558 lbs. were brought direct from Spain, and 13,714 lbs. from Gibraltar; of the latter a part was derived from Carniola, and a part from Spain; 31,014 lbs. were brought from Italy. Only 192,310 lbs. were retained for home consumption in 1831. Quicksilver is produced in several of the provinces of China. During the war, when the intercourse between Europe and America was interrupted, the price of quicksilver rose to such a height in the latter that it answered to import it from China; but since the peace it has been regularly exported to the latter. At an average of the 14 years ending with 1828, the imports of quicksilver by the English and Americans into Canton amounted to 648,085 lbs a-year, worth 340,262 dollars. The sulphuret is found in abundance in California; the boulders being mostly composed of native cinnabar. From the attention of the population being wholly turned on gold, these stones were neglected, and the quicksilver necessary for amalgamating, was imported from China. Besides its uses in medicine, mercury is extensively employed in the amalgamation of the noble metals, in water-gilding, the making of vermillion, the silvering of looking-glasses, the making of barometers and thermometers, &c.

It has been long well known that quicksilver may be most readily extracted from cinnabar, by heating it in contact with quicklime. The sulphur of the cinnabar combines, by virtue of a superior affinity with the lime, to the exclusion of the quicksilver, to form sulphurets of lime and calcium, both of which being fixed *hepars*, remain in the retort while the mercury is volatilized by the heat. In a few places, hammerschlag, or the iron cinder, driven off from the blooms by the tilting hammer, has been used instead of lime in the reduction of this mercurial ore, whereby sulphurous acid and sulphuret of iron are formed.

The annual production of the Bavarian Rhine provinces has been estimated at from 400 to 550 quintals; that of Almaden, in the year 1827, was 22,000 quintals; and of Idria, at present, is not more than 1500 quintals. Those of Guanca Velica average 1800 quintals.

All the plans hitherto prescribed for distilling the ore along with quicklime are remarkably rude. In that practised at Landsberg by Obermoschel, there is a great waste of labor, in charging the numerous small cucurbits; there is a great waste of fuel in the mode of heating them; a great waste of mercury by the imperfect luting of the retorts to the receivers, as well as the imperfect condensation of the mercurial vapors; and probably a considerable loss by pilfering.

The modes practised at Almaden and Idria are, in the greatest degree, barbarous; the ores being heated upon open arches, and the vapors attempted to be condensed by inclosing them within brick or stone and mortar walls, which can never be rendered either sufficiently tight or cool.

To obviate all these inconveniences and sources of loss, the proper chemical arrangements suited to the present improved state of the arts ought to be adopted, by which labor, fuel, and mercury, might all be economized to the utmost extent. The only apparatus fit to be employed is a series of cast-iron cylinder retorts, somewhat like those employed in the coal-gas works, but with peculiarities suited to the condensation of the mercurial vapors. Into each of these retorts, supposed to be at least one foot square in area, and 7 feet long, 6 or 7 cwts. of a mixture of the ground ore with the quicklime, may be easily introduced, from a measured heap, by means of a shovel. The specific gravity of the cinnabar being more than six times that of water, a cubic foot of it will weigh more than 3¼ cwts.; but supposing the mixture of it with quicklime (when the ore does not contain the calcareous matter itself) to be only thrice the density of water, then four cubic feet might be put into each of the above retorts, and still leave 1¼ cubic feet of empty space for the expansion of volume which may take place in the decomposition. The ore should be ground to a moderately fine powder, by stamps, iron cylinders, or an edge wheel, so that, when mixed with quicklime, the cinnabar may be brought into intimate contact with its decomposer, otherwise much of it will be dissipated unproductively in fumes, for it is extremely volatile.

A new process for the distillation of mercury has been proposed by M. Violette. It consists in immersing the mass in a current of the vapor of water, heated from 320° to 400° cent. The vapor acts at once as the heating and the mechanical agent: it first heats the metal so as to produce distillation, and then drives before and draws over the mercurial vapor just as a hot current of air promotes the evaporation of water. The steam charged with the mercurial vapor is condensed in a common refrigerator. The metal separates at the bottom of the receiver, while the condensed water floats above. The liquid thread which flows from the refrigerator consists of two parts; an upper one, which is water, and the under one, the mercurial thread: there is a continuous current of both. No bumping occurs, the operation going on as quietly as the distillation of water. The apparatus employed consists of a cast-iron cylindrical retort receiving the vessel which contains the mercury; an iron worm, which, being heated, the water circulates through it, enters the retort, and traverses it from one end to the other, the mercury being immersed in it; it then escapes with the mercurial vapor, and both are condensed in the refrigerator. This operation is simple and easy: one workman can manage an apparatus with 2000 lbs. of amalgam. There is greater economy of fuel and amalgam. In ordinary process, the latter loss is 2 per cent.; by this there is none, and there is no danger to public health.

Quicksilver is a substance of paramount

value to science. Its great density and its regular rate of expansion and contraction by increase and diminution of temperature, give it the preference over all liquids for filling barometric and thermometric tubes. In chemistry it furnishes the only means of collecting and manipulating, in the pneumatic trough, such gaseous bodies as are condensable over water. To its aid, in this respect, the modern advancement of chemical discovery is pre-eminently due.

This metal alloyed with tin-foil forms the reflecting surface of looking-glasses, and by its ready solution of gold or silver, and subsequent dissipation by a moderate heat, it becomes the great instrument of the arts of gilding and silvering copper and brass. The same property makes it so available in extracting these precious metals from their ores. The anatomist applies it elegantly to distend and display the minuter vessels of the lymphatic system, and secretory systems, by injecting it with a syringe through all their convolutions. It is the basis of many very powerful medicines.

Mercury dissolves all the metals except iron, forming amalgams with them. With arsenic and antimony by heat.

Mercury may be cleansed by forcing it through chamois leather, hazel wood, or a cone of fine paper. Sometimes it is shaken in a bottle with powdered loaf-sugar, and then passed through a paper funnel. If mixed with other metals, it should be distilled.

The nitrate of mercury is employed for the *secretage* of rabbit and hare-skins, that is, for communicating to the fur of these and other quadrupeds the faculty of felting, which they do not naturally possess. With this view the solution of that salt is applied to them lightly in one direction with a sponge. A compound amalgam of zinc and tin is probably the best exciter which can be applied to the cushions of electrical machines.

The only mercurial compounds which are extensively used in the arts, are factitious cinnabar or vermillion, and corrosive sublimate.

MERCURY, BICHLORIDE OF; is made by subliming a mixture of equal parts of persulphate of mercury, prepared as below described, and sea-salt, in a stoneware cucurbit. The sublimate rises in vapor, and incrusts the globular glass capital with a white mass of small prismatic needles. Its specific gravity is 5·14. Its taste is acrid, stypto-metallic, and exceedingly unpleasant. It is soluble in 20 parts of water, at the ordinary temperature, and in its own weight of boiling water. It dissolves in 2½ times its weight of cold alcohol. It is a very deadly poison. Raw white of egg swallowed in profusion, is the best antidote. A solution of corrosive sublimate has been long employed for preserving soft anatomical preparations. By this means the corpse of Colonel Morland was embalmed in order to be brought from the seat of war to Paris. His features remained unaltered, only his skin was brown, and his body was so hard as to sound like a piece of wood when struck with a hammer.

MERCURY, PROTOCHLORIDE OF. This compound, so much used by medical practitioners, is commonly prepared by triturating four parts of corrosive sublimate along with three parts of running quicksilver in a marble mortar, till the metallic globules entirely disappear, with the production of a black powder, which is to be put into a glass balloon, and exposed to a subliming heat in a sand bath. The calomel, which rises in vapor, and attaches itself in a crystalline crust to the upper hemisphere of the balloon, is to be detached, reduced to a fine powder, or levigated and elutriated. 200 lbs. of mercury yield 236 of calomel and 272 of corrosive sublimate.

The following more economical process is that adopted at the Apothecaries' Hall, London. 140 pounds of concentrated sulphuric acid are boiled in a cast-iron pot upon 100 pounds of mercury, till a dry phosphate is obtained. Of this salt, 124 pounds are triturated with 81 pounds of mercury, till the globules disappear, and till a protosulphate be formed. This is to be intimately mixed with 68 pounds of sea-salt, and the mixture, being put into a large stone-ware cucurbit, is to be submitted to a subliming heat.

From 190 to 200 pounds of calomel rise in a crystalline cake, as in the former process, into the capital; while sulphate of soda remains at the bottom of the alembic. The calomel must be ground to an impalpable powder, and elutriated. The vapors, instead of being condensed into a cake within the top of the globe or in a capital, may be allowed to diffuse themselves into a close vessel, containing water in a state of ebullition, whereby the calomel is obtained at once in the form of a washed impalpable powder. Calomel is tasteless and insoluble in water. Its specific gravity is 7·176.

MERCURY (FULMINATING). A *fulminating* preparation of mercury is obtained by dissolving 100 grs. in 1½ oz., by measure, of nitric acid. This solution is poured (cold) into 2 oz., by measure, of alcohol, in a glass vessel, and heat is applied till effervescence is excited, though it ordinarily comes on at common temperatures. A white vapor undulates on the surface, and a powder is gradually precipitated, which is immediately to be collected on a filter, well washed, and cautiously dried. 100 grains of quicksilver affords 130 grs. of salt. 100 parts of it consists of—

Peroxide of Mercury..........	76
Fulminic acid..................	24
	100

When well-made, it undergoes no change from weather. It is in white grains, or short needles, when pure; it detonates when struck, or on being heated to 370° F. This powder detonates loudly by gentle heat or friction. It is used as the match-powder, or priming, for the percussion caps of detonating locks. Two grs. and a half of it, mixed with one-sixth of that weight of gunpowder, form the quantity for one percussion cap.

A soft mastic varnish is the best for making it adhere to the cap. These caps are sold in Paris for three francs per thousand.

MERCURY (SULPHURETS OF). There are two sulphurets, the black and the red, or the *proto-sulphuret*, and the *deuto-sulphuret*. The first is formed by rubbing vigorously in a glass or porcelain mortar three parts of sulphur and one of mercury, or by adding mercury at intervals, and with agitation, to its own weight of melted sulphur. The second, which is commonly called *cinnabar*, or *vermilion*, is formed by subliming the proto-sulphuret. The process consists in grinding together 150 lbs. of sulphur and 1080 of quicksilver, and then heating the mixture in a cast-iron pot, two and a half feet in diameter and one foot deep, precautions being taken that the mixture does not take fire. The calcined Ethiops is then ground to powder, and introduced into pots capable of holding twenty-four oz. of water each, to which are attached subliming vessels, or bolt heads of earthenware. The sublimation usually takes thirty-six hours, when the sublimers are taken out of the furnace, cooled and broken.

It is this compound which is the most valuable native ore for obtaining the metal from. The beautiful red is obtained by sublimation; when native, it is dark colored.

METALS are a very numerous class of simple bodies, and are distinguished by their very peculiar lustre arising out of their opacity and reflective power in regard to light. They conduct electricity and heat; and they have not been resolved into other forms of matter, so that they are regarded as simple or elementary substances. When their compounds are electrolysed the metals appear at the negative surface, and are hence considered as electro-positive bodies. They are enumerated in the following table, together with the names of the chemists by whom they were discovered, the date of their discovery, their specific gravities, melting points, equivalent or atomic weights, and symbolic abbreviations. For their individual distinctive characters, see the respective metals.

Names of Metals.	Authors, and Dates of their Discovery.	Specific Gravity.	Melting Points.	Equivalent Weights.	Abbreviations or Symbols.
			Fahr.		
1. Gold...... ☉	(Known to the ancients, and represented by the annexed planetary symbols, with which they were supposed to be mysteriously connected.)	19·25	2016°	200	au.
2. Silver..... ☽		10·47	1873	110	ag.
3. Iron...... ♂		7·78	2800 ? s. f. *	28	fe.
4. Copper.... ♀		8·89	1996	64	cu.
5. Mercury.. ☿		13·56	39	200	hg.
6. Lead...... ♄		11·35	612 .. .	104	pl.
7. Tin........ ♃		7·29	442	58	st.
8. Antimony	Basil Valentine...... 1490	6·70	....	65	sb.
9. Bismuth......	Agricola 1530	9·80	497	72	bi.
10. Zinc..........	Paracelsus?......... 1530	7·00	773	82	zn.
11. Arsenic.....	Brandt............. 1733	5·88	....	38	ar.
12. Cobalt......		8·53	2810?	30	co.
13. Platinum......	Wood. 1741	20·98	oh. bp.†	96	pl.
14. Nickel........	Cronstadt.......... 1751	8·27	2810?	28	ni.
15. Manganese....	Gahn. 1774	6·85	s. f.	28	mn.
16 Tungsten......	D'Elhuiart.......... 1781	17·60	....	100	tu.

* Smith's Forge. † Oxy-hydrogen blow-pipe.

Names of Metals.	Authors, and Dates of their Discovery.	Specific Gravity.	Melting Points.	Equivalent Weights.	Abbreviations or Symbols.
			Fahr.		
17. Tellurium	Müller 1782	6·11	620?	32	te.
18. Molybdenu	Hielm 1782	7·40	oh. bp.	48	mo
19. Uranium..m	Klaproth 1789	9·00	oh. bp.	217	ur.
20. Titanium	Gregor 1791	5·30	oh. bp.	24	ti.
21. Chromium	Vauquelin 1797	....	oh. bp.	28	cr.
22. Columbium	Hatchett 1802	....	oh. bp.	185	col.
23. Palladium	Wollaston 1805	11·50	....	54	pl.
24. Rhodium		....	oh. bp.	45	rh.
25. Iridium	Tennant 1803	....	oh. bp.	96	ir.
26. Osmium		....	oh. bp.	100	os.
27. Cerium	Hisinger 1804	....	....	48	ce.
28. Potassium	Davy 1807	0·86	186	40	po.
29. Sodium		0·97	190	24	so.
30. Barium		....	....	70	ba.
31. Strontium		....	....	44	sr.
32. Calcium		....	....	20	ca.
33. Cadmium	Stromeyer 1818	8·60	442	56	cd.
34. Lithium	Arfwedson 1818	....	....	10	li.
35. Silicium	Berzelius 1824	....	....	8	si.
36. Zirconium		....	....	30	zr.
37. Aluminum	Wöhler 1828	....	....	10	al.
38. Glucinum		....	....	18	gl.
39. Yttrium		....	....	32	yt.
40. Thorium	Berzelius 1829	....	....	60	th.
41. Magnesium	Bussy 1829	....	....	12	mg.
42. Vanadium	Seftström 1830	....	....	68	va.
43. Pelopium	H. Rose 1843	....	....	..	pe.
44. Niobium	H. Rose 1843	....	....	..	nb.
45. Erbium	Mosander "	....	....	..	er.
46. Terbium	Mosander "	....	....	..	tr.
47. Ruthenium	Claus 1844	....	....	..	ru.
48. Aridium	Ulgreu 1850	....	....	..	ar.
49. Lanthanum	Mosander 1842	....	....	..	lu.
50. Didymium	Mosander "	....	....	..	dy.
51. Norium	Svanberg 1845	....	....	..	no.

The specific characters of minerals are three. Specific gravity, hardness, and crystaline form, which last is either rhombohedral, pyramidal, prismatic, or tessular; *i. e.*, hexagonal. A collection of similar species are a genus, of generas an order, and of orders a class.

There are seven metals with proven alkaline bases; potassium, sodium, barium, strontium, calcium, magnesium, and lithium.

There are six with earthy bases; aluminum, glucinum, cerium, yttrium, zirconium, and thorium; *i. e.*, formed by reducing the earths to metals by abstracting oxygen from the earths. When these metals are oxidized, the products are white powders, without flavor. The rest of the metals can hardly be classed together, as they have few properties in common.

Oxides of iron, nickel, cobalt, and manganese, are irreducible in fire, but dissolve in acids.

Oxides of gold, platinum, and four others, are reduced to the metallic state by heat alone, and they require great heat to oxidate them.

Metals, in general, seek to return to their original state as oxides, with two or three exceptions of the harder kinds, arising apparently from the excess of a silicious or quartz base over the alkali, combined during their electrical generation.

Despretz gives the following table of the conducting heat of metals according to the following figures:—

Gold, 1000; platinum, 981; silver, 973; copper, 898; iron, 374; zinc, 363; tin, 304; lead, 179·6.

Becquerel gives the electrical conducting power as follows:—

Copper, 100; gold, 93·6; silver, 73·6; zinc, 28·5; platina, 16·4; iron, 15·8; tin, 15·5; lead, 8·3; mercury, 3·5; potassium, 1·33.

The most *ductile* and *malleable* of the metals, in order, are cadmium, copper, gold, iridium, iron, lead, &c.; and tin and zinc the least.

The most brittle, are, antimony, arsenic, bismuth; and tungsten, titanium, and uranium the least.

The most facile for wire poles, in order, are gold, silver, platinum, iron, copper, zinc, tin, lead, and nickel.

The easiest made into plates, or sheets, by rollers, in order, are gold, silver, copper, tin, platinum, zinc, iron, and nickel.

When metals require to be *granulated* for manufacturing purposes, they are poured into water, or briskly agitated in a box while congealing, by which they fall into powder instead of crystalizing. A cullender, or ladle with holes, is used in dropping into water.

Silver may be reduced to fine grains by first dissolving it in nitric acid, and then immersing a plate of copper, to which the silver will attach itself; but it must be shaken off till the greater part of the silver has settled at the bottom, when the copper and solution may be taken away, and the precipitate washed and dried.

Copper may be obtained in grains in like manner, by immersing a plate of iron in a solution of the copper and sulphuric acid. When the iron plate is put in, a little more sulphuric acid should be added, and the copper will fall to the bottom, after which it should be washed with dilute sulphuric acid, and with water, and dried.

To obtain gold in powder, dissolve it in muriatic acid, and then add protosulphate of iron. The gold will be precipitated, and then it should be washed with some muriatic acid, and with water, and dried.

Platina may be had in fine powder, by dissolving it in ammonia-muriate, and heating it in a crucible to redness, till no more fumes arise. It then resembles sponge.

Zinc is reducible to fine powder when hot, if pounded by a heated iron mortar in a heated pestle.

When platina is alloyed with other metals, it becomes soluble with them.

Besides the *alloys* enumerated as alloys, steel 500, and silver 1, produce a fine cutting metal.

Steel, too, alloys with rhodium, in razors made at Sheffield; and with gold and nickel, also with platinum, in the proportion 1 platinum, 8 steel, with the finish polish.

All the metallic nitrates are soluble. The muriates generally. The sulphates are insoluble, except by solutions of barytic salts. The acetates are soluble. The alkaline earths are soluble in solutions of sugar. Tortrates render many metallic oxides soluble.

Dr. Thomson divides metals into four classes. 1. *Malleable metals.* Platina, gold, silver, nickel, mercury, palladium, rhodium, iridium, osmium, copper, iron, tin, lead, and zinc. 2. *Brittle and easily fused.* Bismuth, antimony, tellurium, and arsenic. 3. *Brittle and difficult of fusion.* Cobalt, manganese, chrome, molybdena, uranium, tungsten, and titanium. 4. *Refractory*, or such as have never yet been reduced. Columbium, tantalium, and cerium.

Metals, like other fusible bodies, have each a fixed temperature, or freezing point, at which they become solid. The specific gravity is considerably affected by the gradual or hasty cooling, or transition from the fluid to the solid state. Hammering renders them harder and more elastic; but this effect is destroyed by ignition.

They combine with hydrogen into *hydrurets*; with carbon, into *carburets*; with sulphur, into *sulphurets*; with phosphorus, into *phosphurets*; with selenium, into *seleniurets*; with boron, into *borurets* (*borides?*); with chlorine, into *chlorides*; with iodine, into *iodides*; with cyanogen, into *cyanides*; with silicon, into *silicides*, and with fluorine, into *fluorides*.

METALLURGY. The act of separating metals from their ores · with an ore perfectly pure the obtaining a pure metal is a metallurgic process. It is not confined however to this, for ores are rarely pure, but contain earthy ingredients, foreign to, and injurious in, the after treatment. The treatment of ores is both mechanical and chemical. The mechanical processes consist in picking, stamping, and washing. Almost all ores are *picked* by old men, women and children. After the larger lumps are broken by the hammer, then use hand hammers on these broken pieces, and then pick and sort on iron trays the richest lumps of ore. These are at once fit for smelting. The very coarsest are thrown aside as useless, and the intermediate lumps, which contain ore and stone, so intermixed as not to be separated by hand, are passed on to undergo the process of *stamping*.

Before describing the refined methods of washing the more valuable ores of copper, silver, lead, &c., it is proper to point out the means of reducing them into a powder of greater or less fineness, by *stamping*, so called from the name *stamps* of the pestles employed for that purpose. Its usefulness is not restricted to preparing the ores; for it is employed in almost every smelting house for pounding clays, charcoal, scoriæ, &c.. A stamping mill or pounding machine consists of several movable pillars of wood, placed vertically, and supported in this position between frames of carpentry. These pieces are each armed at their under end with a mass of iron. An arbor or axle, moved by water, and turning horizontally, tosses up these wooden pestles, by means of wipers or cams, which lay hold of the shoulders of the pestles. These are raised in succession, and fall into an oblong trough below, scooped out in the ground, having its bottom covered either with plates of iron, or hard stones. In this trough, beneath these pestles, the ore to be stamped is allowed to fall from a hopper above, which is kept constantly full.

The trough is closed in at the sides by two partitions, and includes three or four pestles; which the French miners call a battery. They are so disposed that their ascent and descent take place at equal intervals of time.

Usually a stamping machine is composed of several batteries (two, three, or four), and the arrangement of the wipers on the arbor of the hydraulic wheel is such that there is constantly a like number of pestles lifted at a time—a circumstance important for maintaining the uniform going of the machine.

The matters that are not to be exposed to subsequent washing are stamped dry, that is, without leading water into the trough; and the same thing is sometimes done with the rich ores, whose lighter parts might otherwise be lost.

Most usually, especially for ores of lead, silver, copper, &c., the trough of the stamper is placed in the middle of a current of water, of greater or less force; which, sweeping off the pounded substances, deposits them at a greater or less distance onwards, in the order of the size and richness of the grain; constituting a first washing, as they escape from beneath the pestles.

After the ore is stamped it undergoes the next process, that of *washing*. This is a tedious and costly operation, and has for its object the separation of the earthy from the metallic part of the ore, and depends upon the fact that the latter is heavier than the former. Before being washed the ore is generally riddled or sifted by hand or machine.

Sometimes, as at Poulläouen, the sieves are conical, and held by means of two handles by a workman; and instead of receiving a single movement, as in the preceding method, the sifter himself gives them a variety of dexterous movements in succession. His object is to separate the poor portions of the ore from the richer; in order to subject the former to the stamp mill.

Among the siftings and washings which ores are made to undergo, the most useful and ingenious are those practised by *iron gratings*, called on the Continent *grilles anglaises*, and the *step-washings* of Hungary, *laveries à grandins*. These methods of freeing the ores from the pulverulent earthy matters, consist in placing them, at their out-put from the mine, upon gratings, and bringing over them a stream of water, which merely takes down through the bars the small fragments, but carries off the pulverulent portions. The latter are received in cisterns, where they are allowed to rest long enough to settle to the bottom. The washing by steps is an extension of the preceding plan. To form an idea, let us imagine a series of grates placed successively at different levels, so that the water, arriving on the highest, where the ore for washing lies, carries off a portion of it, through this first grate upon a second closer in its bars, thence to a third, &c., and finally into labyrinths or cisterns of deposition.

In certain mines of the Hartz, tables called *à balais*, or *sweeping tables*, are employed. The whole of the process consists in letting flow, over the sloping table, in successive currents, water charged with the ore, which is deposited at a less or greater distance, as also pure water for the purpose of washing the deposited ore, afterwards carried off by means of this sweeping operation.

At the upper end of these *sweep-tables*, the matters for washing are agitated in a chest, by a small wheel with vanes, or flap-boards. The conduit of the muddy waters opens above a little table or shelf; the conduit of pure water, which adjoins the preceding, opens below it. At the lower part of each of these tables, there is a transverse slit, covered by a small door with hinges, opening outwardly, by falling back towards the foot of the table. The water spreading over the table, may at pleasure be let into this slit, by raising a bit of leather which is nailed to the table, so as to cover the small door when it is in the shut position; but when this is opened, the piece of leather then hangs down into it. Otherwise the water may be allowed to pass freely above the leather, when the door is shut. The same thing may be done with a similar opening placed above the conduit. By means of these two slits, two distinct qualities of *schlich* may be obtained, which are deposited into two distinct conduits or canals. The refuse of the operation is turned into another conduit, and afterwards into ulterior reservoirs, whence it is lifted out to undergo a new washing.

In the percussion tables, the water for washing the ores is sometimes spread in slender streamlets, sometimes in a full body, so as to let two cubic feet escape per minute. The number of shocks communicated per minute, varies from 15 to 36; and the table may be pushed out of its settled position at one time, three quarters of an inch, at another nearly 8 inches. The coarse ore-sand requires in general less water, and less slope of table, than the fine and pasty sand.

The *mechanical* operations which ores undergo, take place commonly at their out-put from the mine, and without any intermediate operation. Sometimes, however the hardness of certain *gangues* (vein-stones), and of certain iron ores, is diminished by subjecting them to calcination previously to the breaking and stamping processes.

When it is intended to wash certain ores, an operation founded on the difference of their specific gravities, it may happen that by slightly changing the chemical state of the substances that compose the ore, the earthy parts may become more easily separable, as also the other foreign matters. With this view, the ores of tin are subjected to a roasting, which by separating the arsenic, and oxidizing the copper which are intermixed, furnishes the means of obtaining, by the subsequent washing, an oxide of tin much purer than could be otherwise procured. In general, however, these are rare cases; so that the washing almost always immediately succeeds the picking and stamping; and the roasting comes next, when it needs to be employed.

The mechanical processes terminate here: the further treatment of them is chemical: this consists chiefly in *calcination* or *roasting*.

The operation of roasting is in general executed by various processes, relatively to the nature of the ores, the quality of the fuel, and to the object in view. The greatest economy have to be studied in the fuel, as well as the labor; two most important circumstances, on account of the great masses operated upon.

Three principal methods may be distinguished; 1, the roasting in a heap in the open air, the most simple of the whole; 2, the roasting executed between little walls, and which may be called case-roasting; and 3, roasting in furnaces.

We may remark, as to the description about to be given of these different processes, that in the first two, the fuel is always in immediate contact with the ore to be roasted, whilst in furnaces, this contact may or may not take place.

The roasting in the open air, and in heaps more or less considerable, is practised upon iron ores, and such as are pyritous or bituminous. The operation consists in general in spreading over a plane area, often bottomed with beaten clay, billets of wood arranged like the bars of a gridiron, and sometimes laid crosswise over one another, so as to form a uniform flat bed. Sometimes wood charcoal is scattered in, so as to fill up the interstices, and to prevent the ore from falling between the other pieces of the fuel. Coal is also employed in moderately small lumps; and even occasionally turf. The ore, either simply broken into pieces, or even sometimes under the form of *schlich*, is piled up over the fuel: most usually alternate beds of fuel and ore are formed.

The fire, kindled in general at the lower part, but sometimes, however, at the middle chimney, spreads from spot to spot, putting the operation in train. The combustion must be so conducted as to be slow and suffocated, to prolong the ustulation, and let the whole mass be equally penetrated with heat. The means employed to direct the fire, are to cover outwardly with earth the portions where too much activity is displayed, and to pierce with holes or to give air to those where it is imperfectly developed. Rains, winds, variable seasons, and especially good primary arrangements of a calcination, have much influence on this process, which requires, besides, an almost incessant inspection at constant intervals.

The manner of *case roasting* has been noticed under the head of the articles alum and iron, to which the reader is referred.

Iron ore is thus roasted in the open air to free it from carbonic acid and water. Sulphuret of copper and iron (pyrites) are so treated to get rid of some of the sulphur: sulphates are, however, apt to fuse and run together into masses which are troublesome afterwards. Open air roasting is rarely as effective as that in the reverberating furnace. It is that best suited for powdery ores, and the flame has a powerfully oxidizing effect. On this, Dr. Ure remarks:—

But in every case where it is desired to have a very perfect roasting, as for blende, from which zinc is to be extracted, for sulphuret of antimony, &c., or even for ores reduced to a very fine powder, and destined for amalgamation, it is proper to perform the operation in a reverberatory furnace. When very fusible sulphurous ores are treated, the workman charged with the calcination must employ much care and experience, chiefly in the management of the fire. It will sometimes, indeed, happen, that the ore partially fuses; when it becomes necessary to withdraw the materials from the furnace, to let them cool and grind them anew, in order to recommence the operation. The construction of these furnaces demands no other attention than to give to the sole or laboratory the suitable size, and so to proportion to this the grate and the chimney that the heating may be effected with the greatest economy.

The reverberatory furnace is always employed to roast the ores of precious metals, and especially those for amalgamation; as the latter often contain arsenic, antimony, and other volatile substances, they must be disposed of in a peculiar manner.

The sole, usually very spacious, is divided into two parts, of which the one farthest off from the furnace is a little higher than the other. Above the vault there is a space or chamber in which the ore is deposited, and which communicates with the laboratory by a vertical passage; which serves to allow the ore to be pushed down, when it is dried and a little heated. The flame and the smoke which escape from the sole or laboratory pass into condensing chambers, before entering into the chimney of draught, so as to deposite in them the oxide of arsenic and other substances. When the ore on the part of the sole farthest from the grate has suffered so much heat as to begin to be roasted, has become less fusible, and when the roasting of that in the nearer part of the sole is completed, the former is raked towards the fire-bridge, and its ustulation is finished by stirring it over frequently with a paddle, skilfully worked, through one of the doors left in the side for this purpose. The operation is considered to be finished when the vapors and the smell have almost wholly ceased; its duration depending obviously on the nature of the ores.

The last department of metallurgy which need be noticed, is the *assaying*. Under the head of *Assay* a general outline of the mode of producing is given: three modes of assaying may be followed. 1st. The mechanical assay. 2nd. Assay by the dry way. 3rd. Assay by the moist way.

1. *Of Mechanical assays.*—These kinds of assays consist in the separation of the substances mechanically mixed in the ores, and are performed by a hand-washing, in a small trough of an oblong shape. After pulverizing with more or less pains the matters to be assayed by this process, a determinate weight of them is put into this wooden bowl with a little water; and by means of certain movements and some precautions, to be learned only by practise, the lightest substances may be pretty exactly separated, namely, the earthy gangues from the denser matter or metallic particles, without loosing any sensible portion of them. Thus a *schlich* of greater or less purity will be obtained, which may afford the means of judging by its quality of the richness of the assayed ores, and which may thereafter be subjected to assays of another kind, whereby the whole metal may be insulated.

Washing, as an assay, is practised on auriferous sands; on all ores from the *stamps*, and even on *schlichs* already washed upon the great scale, to appreciate more nicely the degree of purity they have acquired. The ores of tin in which the oxide is often disseminated in much earthy gangue, are well adapted to this species of assay, because the tin oxide is very dense. The mechanical assay may also be employed in reference to the ores whose metallic portion presents a uniform composition, provided it also possesses considerable specific gravity. Thus the ores of sulphuret of lead (galena) being susceptible of becoming almost pure sulphurets (within 1 or 2 *per cent.*) by mere washing skilfully conducted, the richness of that ore in pure galena, and consequently in lead, may be at once concluded; since 120 of galena contain 104 of lead, and 16 of sulphur. The sulphuret of antimony mingled with its gangue may be subjected to the same mode of assay, and the result will be still more direct, since the crude antimony is brought into the market after being freed from its gangue by a simple fusion.

Of Assays by the dry way.—The assay by the dry way has for its object, to show the nature and proportion of the metals contained in a mineral substance. To make a good assay, however, it is indispensably necessary to know what is the metal associated with it, and even within certain limits, the quantity of the foreign bodies. Only one metal is commonly looked after; unless in the case of certain argentiferous ores. The mineralogical examination of the substances under treatment, is most commonly sufficient to afford data in these respects; but the assays may always be varied with different views, before stopping at a definite result; and in every instance, only such assays can be confided in, as have been verified by a double operation.

This mode of assaying requires only a little experience, with a simple apparatus; and is of such a nature as to be practised currently in the smelting works. The air furnace and crucibles employed are described in all good elementary chemical books. These assays are usually performed with the addition of a flux to the ore, or some agent for separating the earthy from the metallic substances; and they possess a peculiar advantage relative to the smelting operations, because they offer many analogies between results on the great scale and experiments on the small. This may even enable us often to deduce, from the manner in which the assay has succeeded with a certain flux, and at a certain degree of heat, valuable indications as to the treatment of the ore in the great way.

For assays in the dry way, both of stony and metallic minerals, the process of Dr. Abich deserves recommendation. It consists in mixing the pulverized mineral with 4 or 6 times its weight of carbonate of baryta in powder, fusing the mixture at a white heat, and then dissolving it, after it cools, in dilute muriatic acid. The most refractory minerals, even corundum, cyanate, staurolite, zircon, and feldspar, yield readily to this treatment. This process may be employed with advantage upon poor refractory ores. The platinum crucible, into which the mixed materials are put for fusion, should be placed in a Hessian crucible, and surrounded with good coke.

It never, however, furnishes exact results. To obtain them it is necessary to resort to *assays by the moist way*, which are regular chemical operations, requiring much skill and experience in chemical analyses. The process generally consists of solution of the ore in acid, determining the insoluble earthy matters (gangue), then taking the clear solution, and separating the several parts of the ore out of the solution by the proper re-agents. The limits of this work do not admit of entering into the processes necessary for individual metals; they are found in the standard works on assaying.

Since the publication of the improved method of making cyanide of potassium, by Liebig, great advance has been made in assaying by the humid way, as this salt possesses the property of separating many metals in mixed solutions.

This salt is the best re-agent for detecting nickel in cobalt. The solution of the two metals being acidulated, the cyanide is to be added until the precipitate that first falls is redissolved. Dilute sulphuric acid is then added, and the mixture being warmed and left in repose, a precipitate does not fail to appear sooner or later, which is a compound of nickel. Cyanide of potassium serves well to separate lead, bismuth, cadmium, and copper, four metals often associated in ores. On adding the cyanide in excess to the solution of these metals in nitric acid, lead and bismuth fall as carbonates, and may be parted from each other by sulphuric acid. Sulphuretted hydrogen is passed in excess through the residuary solution, and the mixture being heated, a small quantity of cyanide is added; a yellow precipitate indicates cadmium; and a black precipitate falls on the addition of hydrochloric acid, if copper be present.

If into a crucible (containing the cyanide fused by heat), a little of any metallic oxide be thrown at intervals, it will be almost immediately reduced to the reguline state. When the fluid mass is afterward decanted, the metal will be found mixed with the white saline matter, from which it may be separated by water.

Even metallic sulphurets are reduced to the state of pure metals by being projected in a state of fine powder into the fused cyanide. When an iron ore is thus introduced, along with carbonate of potash or soda, and the mixture is heated to fusion, which requires a strong red heat, the alumina and silica of the ore fuse into a slag; from which, on cooling, the metallic iron may be separated by the action of water, and then weighed. If manganese exist in the ore, it remains in the state of protoxide; to be determined by a separate process. When oxide of copper is sprinkled on the surface of the fused cyanide, it is immediately reduced, with the disengagement of heat and light. The mixture being poured out of the crucible and concreted, is to be ground and washed, when a pure regulus of copper will be obtained.

The process of reduction is peculiarly interesting with the oxide of antimony and tin; being accomplished at a low red heat, hardly visible in daylight. Even the sulphurets of these metals are immediately stripped of their sulphur, with the formation of sulpho-cyanide of potassium.

Cyanide of potassium, mixed with carbonate of soda, is an excellent re-agent in blow-pipe operations for distinguishing metals. The reductions take place with the utmost facility, and the fused mixture does not sink into the charcoal, as carbonate of soda alone is apt to do in such cases. Hence the grains or bends of metal are more visible, and can be better examined.

When the cyanide is heated along with the nitrates and chlorates (of potash), it causes a rapid decomposition, accompanied with light and explosions.

Arsenic may be readily detected in the commercial sulphuret of antimony, by fusing it with three-fourths of its weight of the cyanide in a porcelain crucible over a spirit-lamp, when a regulus of antimony is obtained. The metal may then be easily tested for arsenic, since none of this volatile substance can have been lost, owing to the low temperature employed.

When arsenious acid, or orpiment, or any of the arseniates, are mixed with six times their weight of the mixture of cyanide and carbonate of soda in a tube with a bulb at one end, and heat applied with a spirit-lamp to the glass, very beautiful rings of metallic mirror are formed by the reduced arsenic. The arseniates of lead and peroxide of iron, however, do not answer the test.

When sulphates of lead and barytes, along with silicia, are mixed with four or five times their weight of the above mixed cyanide and carbonate, and fused, the sulphate of lead is reduced to the metallic state, the sulphate of barytes becomes a carbonate, and the silica gets combined with the alkali into a soluble glass.

METEORITES are stones of a peculiar aspect and composition, which have fallen from the air.

METER. An instrument for measuring *gas*. When gas commenced to be used extensively, it was found necessary to have some check upon the gas-works as well as the public, as a means of calculating between the works and large consumers, and indicating accurately the amount consumed. This has been, to a great extent, accomplished by the gas-clock or gas-meter. The principle in the construction is simple. When a number of vessels of a certain capacity, say 1 cubic foot, are so arranged that (without loss of gas in the interval) one after the other shall be filled by the gas in passing, and for this purpose are inverted in water, into which the gas enters, just as is the case on a large scale with the gasometer; it follows, that just as many cubic feet of gas will have passed, as there are air-vessels that have filled. If these vessels be attached to a common axis, upon which they revolve as they fill and rise, every revolution will correspond with 4 cubic feet of gas that have passed through. In the actual gas-meter, instead of separate vessels, compartments of a drum of equal and known capacity are used. The drum revolves in a case more than half filled with water (dilute alcohol in winter), and is divided by 4 crooked partitions into as many chambers. The contents of each chamber are closed at the front and back by the straight sides of the drum, above, by the crooked partition, and below by the water. The tube for the admission of the gas enters at the back, and delivers into the uppermost box; as this fills it becomes lighter, and rising, revolves on its axis until it gets above the level of the water, when it parts with the gas through a narrow slit into the space above, when the gas is carried on into the consuming pipe. The moment one chamber is emptied, another is filled with water and placed above the pipe, which enters from the back; it becomes filled and acts similarly to the first, and so on, with the four. To the axis of the drum is attached a toothed wheel, which turns a hand by means of works upon a clock plate, which has generally 3 dials, indicating 1, 10, and 100 revolutions, and thus the quantity of gas which has passed is ascertained in cubic feet.

In practice, the construction of the wet metre admits of fraud being practised with it. If, for instance, the water level be lowered, more gas will pass through than will be registered; if the meter be tilted forward and some of the fluid drawn out, gas will pass through without being registered at all.

These objections have given rise to the

use of *dry* meters, in which any fluid in the box is dispensed with. In dry meters, the gas is measured by the number of times that a certain bulk will fill a chamber capable of undergoing contraction and expansion by the passage of the gas. These alternate contractions and expansions of the chamber, set valves in motion, which, aided by light arms and wheels, turn the hand of a dial, as in the wet meter. The largest meter yet constructed is one by Mr. Defries, on the dry meter plan, for the registering the gas used in Covent Garden Theatre, London. It is said to be very accurate in its measurements. It contains two chambers: the upper one holds the machinery; the lower is divided into 6 compartments by three movable diaphragms, and 3 fixed partitions. The gas enters at the inlet pipe, whence it passes through the bottom of the meter, and fills each compartment in succession, a continuous supply is kept up by the action on the movable diaphragms, which acts on the indicating machinery by means of a very simple and ingenious contrivance that registers the consumption of gas with unerring accuracy on a plate of 6 dials and indexes, from units to millions. This meter is capable of measuring 6000 cubic feet per hour, and is to measure the supply of 1500 burners. It weighs 2 tons, is 16 feet in circumference, and 8 in height. The shape is a sexagon, with gothic devices.

The wet gas-meter can be made to indicate favorably for the gas companies, and it is more frequently in error on that side, than favoring the consumer; the dry meter does not appear to be based on true philosophical principles, and will, in all likelihood, not hold its ground. A correct meter is still a desideratum.

METHYLENE, a peculiar liquid compound of carbon and hydrogen, extracted from pyroxylic spirit. which is reckoned to be a bi-hydrate of *methylène*.

MICA is a finely foliated mineral, of a pearly metallic lustre. It is harder than gypsum, but not so hard as calc-spar; flexible and elastic; spec. grav. 2·65. It is an ingredient of granite and gneiss; in this country commonly called isinglass; in Europe it is occasionally called Muscovy-talc. The largest sheets are found in Siberia, Canada, and the New England States. Its primitive form is an oblique rhombic prism; ordinarily it is a six-sided table; its cleavage is perfect. There is great diversity in the composition of mica coming from different localities; generally it is a silicate of alumina united with silicates of iron and potash. Sometimes manganese replaces the alumina, as in the mica of Mt. St. Gothard; sometimes magnesia replaces the potash, and titanium the iron. That from Siberia yielded to Klaproth, in 100 parts:

Alumina..............	34·25
Silica..................	48·00
Oxide of iron..........	4·50
Oxide of Manganese....	trace
Magnesia................	0·50
Potash.................	8·75

The mica of Fahlun, analyzed by Rose, afforded, silica, 46·22; alumina, 34·52; peroxide (?) of iron, 6·04; potash, 8,22; magnesia, with oxide of manganese, 2·11; fluoric acid, 1·09; water, 0·98.

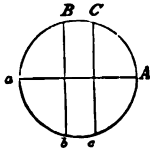
Very beautiful specimens of mica abound in the United States. At Acworth, N. H., they lie imbedded in felspar; at Monroe, N. Y., a large vein of a green-colored variety exists. The crystals at Goshen, Mass., are rose-red, and rhomboidal, and that in Brunswick, Me., is in emerald green scales. *Lepidolite* is a variety of mica containing lithia and fluoric acid; it occurs at Paris, Maine. Brown and gray mica are used in lanterns, in stove-doors, and in the windows of ships of war, and in all cases where glass is liable to be broken.

It is much used in optical experiments, and in the manufacture of artificial ultra marine.

MICROCOSMIC SALT. A term given to a salt extracted from human urine, because man was regarded by the alchemists as a miniature of the world, or the microcosm. It is a phosphate of soda and ammonia; and is now prepared by mixing equivalent proportions of phosphate of soda and phosphate of ammonia, each in solution, evaporating and crystallizing the mixture. A small excess of ammonia aids the crystallization.

MICROMETER. An instrument applied to telescopes and microscopes for measuring very small distances, or the diameters of objects which subtend very small angles. A great number of contrivances of various kinds, and depending on different principles, have been employed for this purpose; but it will be sufficient to give a general description of some of the most useful or remarkable ones.

Wire Micrometer.—This instrument, when placed in the tube of a telescope, at the focus of the object glass, presents



the appearance represented in the annexed figure. A *a* is a spider's web line, or very fine wire, fixed to the diaphragm; and B *b* and C *c* are similar wires stretched across two forks, each connected with a milled-headed screw. By means of these screws the two wires, B *b* and C *c*, which are exactly parallel to each other, are movable in the direction perpendicular to *A a;* and, in order that the wire A *a* may be placed in any direction relatively to the meridian, there is an adjusting screw, which works into an interior toothed wheel, and turns the apparatus round in its own plane perpendicular to the axis of the telescope.

The method of using the micrometer is as follows: Suppose the object to be accomplished were the measurement of the *angle of position* and distance of two very close stars; the telegraph being set and kept on the objects, the micrometer is turned by its adjusting screw until the spider line A *a* coincides with the line joining the two stars, or *threads* them both at the same moment. The milled heads of the screws which carry the two movable wires, are then turned until B *b* bisects one of the two stars, and C *c* bisects the other. The observation is now completed, and it only remains to ascertain the position and distance indicated by the micrometer. For the first of these purposes, the circumference of the micrometer is divided into degrees and minutes, and read by two verniers: this reading gives the position of A *a* in respect of the horizontal and vertical planes, and consequently the angle of position of the two stars. To find their distance, the head of the screw which carries one of the movable wires, for instance C *c*, is turned until C *c* coincides with B *b;* and the number of revolutions, and parts of a revolution, required to effect the coincidence, gives the distance of the stars when the value of the *scale* of the micrometer is known; that is to say, when the number of seconds of space which correspond to one revolution of the screw is known. The screws must be made with great accuracy, and their heads are usually divided into 60 equal parts, representing seconds.

The value of the scale, or of a revolution of the screw, is obtained in the following manner: Set the two wires, B *b* and C *c*, apart to a certain number of revolutions, and place them in the direction of the meridian. Observe the transits of several stars of known declination over the wires; then multiply each interval of seconds by 15, and by the cosine of the star's declination; and, taking the mean, you have the seconds of space which correspond to a known number of revolutions of the screw.

Circular Micrometer.—This instrument, which differs entirely from the above, was first suggested by Boscovich, in the *Leipzic Acts* for 1740, and used by Lacaille in observing a comet in 1742; but seems afterwards to have fallen into disuse, until it was revived by Dr. Olbers, about 1798. The principle may be explained as follows: If the field of a telescope be perfectly circular (which may be effected by means of a diaphragm turned in a lathe), and if its diameter be determined from observation, the paths of two celestial bodies across the field may be considered as two parallel chords, which are given in terms of a circle of known diameter. The differences of the times at which two stars arrive at the middle of their paths will be their ascensional differences; and the distance between the chords, which is readily computed from their lengths, gives the difference of the declination of the two bodies.

The most approved construction of the annular micrometer is that of the late Fraunhofer. It consists of a disk of parallel plate glass, having in its centre a round hole of about half an inch in diameter, to the edges of which a ring of steel is cemented, and afterwards truly turned in a lathe. The disk being mounted in a brass tube, so that it may be accurately adjusted in the focus of the eyepiece, and applied to a telescope, the steel ring is alone visible, and appears as if suspended in the atmosphere, whence the instrument is called the *suspended annular micrometer*.

The micrometer is an instrument of the utmost importance in astronomy, and one, in fact, to which that science is as much indebted as to the telescope itself. From a paper by Mr. Townley, in the *Phil. Trans.* for 1667, it appears certain that a micrometer with a movable wire was first constructed by an Englishman, Gascoigne, about the year 1640, and used by him for measuring the diameters of the moon and some of the planets; but as Gascoigne, who was killed in the civil wars in 1644, published no account of his invention, the instrument was entirely forgotten, and the merit of reinventing it, and bringing it into general use, belongs to the French astronomer Azout, who published a description of it in 1667. Huygens, a few years previously, had contrived to measure the diameter of a planet by inserting in the tube of a telescope, at the focus of the object-glass and eye-glass, a slip of metal which covered exactly the image of the planet, and then deducing the diameter from the breadth of the slip, compared with the diameter of the field; and Malvasia had employed for the same purpose a reticle or network of fine silver wires, crossing each other at right angles, and dividing the field of the telescope into a number of equal squares.

MICROPHONE. An instrument for increasing the intensity of low sounds, by subjecting a more sonorous body than that which emits the sound to be affected by the vibrations of that body, and thereby also sounding itself.

MILDEW. This term is generally applied to a particular mouldy appearance on the leaves of plants, which is produced by innumerable minute fungi, which if not checked in their growth will occasion the decay and death of the parts on which they grow, and sometimes of the entire plant. In agriculture, this appearance is frequently termed rust, and sometimes blight. It is common on wheat, and on the hop; and, in gardens, on the leaves of the peach, the nectarine, and other fruit trees. The causes favorable to the production of mildew are a rich soil and a moist atmosphere, without a free circulation of air or sunshine. In agriculture, this parasitical disease is generally considered without remedy; but, in gardening, it may be checked by the application of powdered sulphur to the leaves covered by the fungi, which is found to destroy them without greatly injuring the leaf. Dry rot is only mildew of a more formidable kind.

MILE. The Roman pace being 5 feet, and a Roman foot being equal to 11·62 modern English inches, it follows that the ancient Roman mile was equivalent to 1614 English yards, or very nearly 11-12ths of an English statute mile.

The English statute mile was defined (incidentally, it would seem) by an act passed in the 35th year of the reign of Queen Elizabeth, by which persons were forbidden to build within three *miles* of London; and the mile was declared to be 8 furlongs of 40 perches of 16½ feet each. The statute mile is, therefore, 1760 yards, or 5280 feet.

MILK owes its whiteness and opacity to an emulsion composed of the caseous matter and butter, with sugar of milk, extractive matters, salts, and free lactic acid; the latter of which causes fresh milk to redden litmus paper. Milk, in general, contains from 10 to 12 per cent. of solid matter, on being evaporated to dryness by a steam heat. The mean specific gravity of cows' milk is 1·030, but it is less if the milk be rich in cream. The specific gravity of the skimmed milk is 1·035; and of the cream is 1·0244. 100 parts of creamed milk contain—

Caseous matter, containing some butter	2·600
Sugar of milk	3·500
Alchoholic extract, lactic acid, and lactates	0·600
Salts; muriate and phosphate of potash, and phosphate of lime	0·425
Water	92·875

Cream consists of—butter separated by churning	4·5
Caceous matter precipitated by the coagulation of the milk of the butter	3·5
Butter-milk	92·0
	100·0

When milk, contained in wire-corked bottles, is heated to the boiling point in a water bath, the oxygen of the included small portion of air under the cork seems to be carbonated, and the milk will afterwards keep fresh, it is said, for a year or two; as green gooseberries and peas do by the same treatment.

Milk is sometimes adulterated with potato starch, which gives it a creamy consistence. This fraud may be detected by pouring a few drops of solution of iodine into it, which immediately gives it a blue or purple tint. Emulsion of almonds, also occasionally used, may be detected by the taste.

The substances most commonly used for the purpose of adulteration appear to be water, flour, starch, and finely powdered chalk.

On examining a little of the milk under the microscope, the peculiar granules of starch and flour may be readily seen, larger and more oval than the milk globules, if either of these substances are present. Should any doubt exist as to their real nature, the addition of a drop or two of the solution of iodine will impart to the farina granules a dark purple color.

The presence of chalk may be still more easily discovered, since, owing to specific gravity, it soon subsides to the bottom of the liquid, where it may at once be recognized by its effervescing on the addition of a little muriatic acid.

We have no chemical means of ascertaining whether water has been fraudulently added to milk, the only effect being to dilute it and render it poor in quality. A knowledge of the specific quantity cannot here be made available, since the abstraction of cream, which has a lower specific gravity than milk, may be made to neutralize the effect produced by the addition of water; the tendency of the removal of the cream being to raise the specific gravity of the fluid, and that of the addition to lower it. A specimen of milk, therefore, which has been impoverished by the abstraction of its cream, and still further weakened by the addition of water, may be made to possess the same specific gravity it had when taken pure from the cow.

A new method of increasing the quantity of cream produced from milk, and preserving milk, has been discovered by Francis Bernard Bekaert, a citizen of Belgium, and we find it thus described in Newton's London Journal for January, 1848, in an account of a patent for the purpose, taken out in England:—"The invention consists, firstly, in a method of increasing the quantity of cream produced from milk, by the addition of one table-spoonful of the liquid, hereafter described, to every quart of new milk; the milk is then stirred once or twice round, and left in the pan or vessel; and the skimming may take place at the expiration of the usual time, but the patentee prefers to delay it a little. He states that, by the application of the liquid, a much larger quantity is forced to the surface of the milk than can be obtained in the ordinary way. The liquid is prepared by adding to one quart of water, one ounce of the carbonate of soda, one tea-spoonful of a solution of turmeric or curcuma, and three drops of marigold water. When making large quantities of the liquid, it is not requisite to weigh the soda, as the same purpose is answered by putting such a quantity of soda into water as will, when dissolved, on application of a salometer known in Belgium, by the denomination of a 'pèreset,' show a density equal to ten degrees. The soda is first mixed with the water, and then the solution of turmeric and the marigold water are added.

"The patentee claims, under this head of his invention, any salt of soda, when mixed as before stated, and applied to milk, for the purpose of causing a larger quantity of cream to rise to the surface of the milk than is procured by the ordinary process. The soda and water form the basis of the improvement, the solution of turmeric and marigold water being only used to improve the color and quality of the butter made from the cream, and not being essentially necessary to effect the increase of the cream. Although the patentee finds the use of the soda most convenient, he claims any other alkali when applied in a similar way.

"The second part of the invention consists in the following method of preserving milk: One table-spoonful of a solution of soda, made by dissolving one ounce of carbonate of soda in a quart of water, is introduced into a quart bottle, nearly filled with new milk, only sufficient space having been left for the spoonful of liquid; after which the bottle is corked, and a piece of string put round the cork to prevent it from flying, and then the bottles are put into a copper or other vessel containing cold water, which is to be gradually brought to the boiling point. When this has been effected, the fire is to be withdrawn from beneath the copper, or the vessel, if movable, is to be taken off the fire, and the water and the contents of the bottles are allowed to cool; the bottles are then taken out of the water and packed away."

Scarcely any idea can be formed of the immense quantity of milk produced in the Union. In forming an approximation to the probable quantity, the following, taken from the patent office reports for 1847 and 1848, may afford some assistance:—

"We have no precise data on which to found an extended estimate, for in none of the census returns of the States do we find the number of milch cows specified. But in the state of New York, in 1845, the amount of butter reported as made was about 80,000,000, and that of cheese 36,000,000 pounds.

"Were we to allow for every pound of butter 25 pounds of milk, which is probably a low average, and reckon these at about 10 or 12 quarts, this would give 800,000,000 or more quarts, or 200,000,000 gallons of milk. But considering the proportion of milk used for butter as one-half throughout the whole State, and this would give for the single State of New York, not less than 400,000,000 of gallons of milk used, besides what is applied to butter and cheese; and were this reckoned at only 2 cents per quart, would be the sum of $82,000,000, while the butter, at only 10 cents per pound, and the cheese at 5 cents per pound, a low estimate for each, would amount to $8,000,000 for butter, and the cheese to $1,800,000, making the aggregate of the milk product of the single state of New York, at a very low estimate, at least $40,000,000,000, equal to two-thirds of the cotton crop of the United States.

"According to the census of the United States in 1840, the number of neat cattle, including all kinds, was for Pennsylvania and Ohio each about one-quarter less than in New York. As it is believed that the number of oxen used in New York is greater than in Pennsylvania and Ohio, supposing a similar ratio to hold good, and modified by this last consideration in these two States with respect to milch kine, we may probably consider the milk product of each of the States of Pennsylvania and Ohio, then, at about one-fifth less than in New York. It is very probable, however, that the proportion would be less with respect to Ohio at the present time. But, allowing it as we have mentioned, we must consider the milk products of Pennsylvania and Ohio equal to at least $64,000,000, and the aggregates for these States and New York would be equal to over $100,000,000. Were this estimate to be extended to the other States, the amount in value must be enormous."

The quantity of *milk* sold *in our cities* is great. Some idea of it may be formed from the fact that 50,000 quarts of milk daily are carried on the Erie railroad, equal, including the cans, to sixty-three tons, not less, probably, than 15,000,000 or 16,000,000 quarts a-year, which did not find its way to New York before the road was constructed.

MILLS are, in the original sense, establishments for grinding grain, &c., but the word is often synonymous with factory or manufactory, and applied to any thing wrought by machinery.

Flour mills have, for ages, been wrought by water and wind, but latterly steam has been applied. The principle is the same in all, the rotation of a stone in juxtaposition with a fixed one, with hopper for supply, and bolter for sifting. Doubts being entertained of the integrity of many millers, various mills for domestic grinding have been invented, as Stockdale's and Rustall's, with detached bolters. Rustall's consists of vertical stones of 30 inches, one of which is turned by a winch, and altogether most complete, and his bolter is equally excellent. It has been adopted in prisons, workhouses, barracks, and other establishments.

The grain falls from the hopper into the eye of the upper mill-stone, and by its revolution is passed between the stones, and thrown out, as flour, meal, or malt. The number of revolutions in a minute ought to be 450, divided by the diameter in feet.

An upper stone, of six feet, contains about 22½ cubic feet, at 840 or 850 lbs. to the foot, and its revolutions about 75 per minute. The water-wheel may be 18 feet, if the floats move with a third of the velocity of the stream.

A sack of wheat per hour may be ground with a power able to raise 900 lbs. 70 feet per minute; for 2, 3, or 4 sacks, the power rises in less ratio than the multiple, *i.e.* 2100 lbs. at 70 feet, would grind three sacks of rye or wheat.

To grind 8 sacks per hour requires a cylinder of a steam-engine of 20 inches, and 1 sack a cylinder of 12·5 inches. To do the same work, 8 and 1 sack, with an overshot water-wheel of 12 feet, requires 1600 and 660 imperial gallons of water; with a wheel of 16 feet, 1200 and 500 imperial gallons; or with a wheel of 24 feet, 800 gallons and 330 per minute.

In a corn-mill, there are three departments. 1. The revolving sieve and fan, to clean the corn before it descends to the hopper. 2. The hopper and the stones. 3. The cooler and vibrating bolter, where it is dressed. A system of buckets raises the grain to the sieve, and the flour to the bolter, by various applications of the moving power.

Bigelow proposes to make holes in the cap or running-wheel, to prevent the heating or clogging of the meal, in cases of increased velocity.

Mill-stones are hard grit or granite-stones, cut into grooves in octagonal sections, so as to cross each other in working, and make the grain pass over the largest surface. Eight radii, at 45°, are first grooved with a double hammer, pick, and chisel, and then six other roads or grooves are chisselled and picked parallel to each of these radii; the stones then work parallel. Some work right-handed, others left-handed, but the grooves must tally.

Flax mills are water-mills, which turn rollers for bruising the rough flax, and revolving or turning spikes or scutchers to clear the flax presented to them. Forty aws for the water-wheel, and 102 cogs for the power, moving another with 25

teeth for the middle roller, are the proportions of Gray.

Flatting mills for reducing metal to plates, are rollers turned by horses, or steam-power, through which the metal is passed and repassed. The distances of the rollers are adjusted by screws, turned by pinions. Lead, copper, and silver are rolled thus, and copper is silvered by rolling a thin plate of silver fixed to a thick one of copper, and, by repeatedly passing through the rollers, constantly narrower or closer, a perfect thin sheet of silvered copper is produced which may be cut or stamped for plated ware, or other purposes.

A *sugar mill* is formed by three upright rollers, the one moving, and the side ones fixed, or sometimes the three moving. The rollers are turned by mules, water, or steam-power, and the canes are placed between the rollers by hand. The expressed juice runs into a trough, and thence into a reservoir.

The following calculations may be usefully given under the head of mill operations: In an *undershot* water-wheel, the *quantity* is the velocity in a second into the area of the water-way. And the *power* is the quantity into the weight of a cubic inch of water, and the velocity. The power is to the effect produced, as 10 to 3·62.

In an *overshot* wheel, the power is the product of the descent from the head to the bottom, and the weight of the water expended in a second. The power is to the effect as 10 to 6·6.

The velocity at a maximum load is three feet in a second.

The velocity is the square root of the space fallen through. For the same stream falling, turns a wheel 57 times in a minute, and directed to the centre as in an undershot wheel, turns it but 38·5 times, which are as 1 to 1·414, the square root of 1 and 2 nearly.

Therefore, the velocities will be as the square roots of their diameters, in all overshot wheels.

Portable horse mills.—The horse is attached to the extremity of a cast-iron lever, which puts in motion a large horizontal wheel, the upright axis of which is sunk into the earth, and having a groove around its rim, which is armed with points of iron; these points enter the links of a chain, which passes around the great wheel, and through two cast-iron trunks, or tubes, which are buried in the earth, under the horse-walk. This chain very conveniently communicates the motion to any distance, and in any direction required; and either of each may be varied *ad infinitum*, without much loss of time, or the employment of any considerable quantity of materials. Two men only were able to re-establish a mill in the course of an hour, in a fresh situation in the open air. The horse is attached to the outer end of the lever, by means of a swingle-tree and traces, which should be as short as possible.

Mr. Bogardus, of New York, has invented an universal eccentric mill for wheeling, cutting, and grinding, which is one of the most useful and important inventions of the time. His patent has been extended by special act of Congress 14 years, in consideration of its great merit.

In Mr. Bogardus's mill the principle is entirely new, both plates revolve in the same direction (with nearly equal speed) on centres, which are apart from each other one inch, more or less; the centre of the one, or axis thereto affixed, resting on, or revolving upon a stationary point, whilst the prime mover, by means of a belt or gearing, communicates motion to the other plate. The circles which are cut in the plates act like revolving shears, cutting every way, which, when in operation, causes a peculiar cutting, wrenching or twisting, and sliding motion, admirably adapted for every species of grinding. From the position of the two centres it is named the *eccentric mill.* The following are some of its advantages:

1. The peculiar motion of the plates will of itself discharge the ground substance; so that many substances can be ground thereby which would altogether choke other mills.

2. In other mills, a given point in one of the plates continually describes the same circle on the other; but in this mill it traverses on the other plate at an infinite variety of angles, every point within two concentric circles apart from each other twice the distance of the centres of the plates, thereby rendering the wear and tear of the plates uniform, and preserving the grinding action of every point.

3. In other mills the grinding power of each point increases with its distance from the centre; but in this mill every point, from the centre to the circumference, has the same grinding power. A considerably smaller mill will therefore effect a given purpose, and the eccentric mill is therefore more portable than other mills.

4. The ever changing action of the mill

and the quick discharge of the substance ground prevented from becoming heated, so that the eccentric mill may be profitably employed in grinding substances which, in other mills, would be either spoiled or deteriorated in quality, or, by their melting, be impossible to be ground. If other mills were driven with that speed which can be safely applied to the eccentric mill, they would be made red-hot in a few minutes.

Bogardus's mills have been successfully introduced for the following purposes: Hulling rice, coffee, and olives. Grinding grain of all kinds; paints of all kinds, in water or oil: iron, zinc, copper, and gold ores, plumbago and manganese; bones for manure, and bones for sugar refining, flint and quartz, charcoal, plaster, putty, printers' inks, drugs and dyestuffs; snuffs, mustard, coffee, spices, loaf-sugar, starch, gums, resins, asphaltum, india-rubber, flax-seed, and oil-cake.

MILL-STONE, or BUHR-STONE. This interesting form of silica, which occurs in great masses, has a texture essentially cellular, the cells being irregular in number, shape, and size, and are often crossed by thin plates, or coarse fibres of silex. The buhr-stone has a straight fracture, but it is not so brittle as flint, though its hardness is nearly the same. It is feebly translucent; its colors are pale and dead, of a whitish, grayish, or yellowish cast, sometimes with a tinge of blue.

The buhr-stones usually occur in beds, which are sometimes continuous, and at others interrupted. These beds are placed amid deposites of sand, or argillaceous and ferruginous marls, which penetrate between them, filling their fissures and honeycomb cavities. Buhr-stones constitute a very rare geological formation, being found in abundance only in the mineral basin of Paris, and a few adjoining districts. Its place of superposition is well ascertained: it forms a part of the lacustrine, or fresh-water formation, which, in the locality alluded to, lies above the fossil-bone gypsum, and the stratum of sand and marine sand-stone which covers it. Buhr-stone constitutes, therefore, the uppermost solid stratum of the crust of the globe; for above it there is nothing but alluvial soil, or diluvial gravel, sand, and loam.

Buhr-stones sometimes contain no organic forms, at others they seem as if stuffed full of fresh-water shells, or land shells, and vegetables of inland growth. There is no except on known to this arrangement; but the shells have assumed a silicious nature, and their cavities are often bedecked with crystals and quartz. The best buhr-stones for grinding corn, have about an equal proportion of solid matter, and of vacant space. The finest quarry of them is upon the high ground, near *La Ferte-sous-Jouarre*. The stones are quarried in the open air, and are cut out in cylinders, from one to two yards in diameter, by a series of iron and wooden wages, gradually but equally inserted. The pieces of buhr-stones are afterwards cut in parallelopipeds, called *panes*, which are bound with iron hoops into large millstones. These pieces are exported chiefly to England and America. Good millstones of a bluish white color, with a regular proportion of cells, when six feet and a half in diameter, fetch 1200 francs a-piece, or $220. A coarse conglomerate sandstone or breccia is, in some cases, used as a substitute for buhr-stones; but it is a poor one.

Very good buhr millstones are now sent from Georgia and Arkansas, which are said to equal the French stone in quality. A set of 5½ feet Georgia stones have been put up in the mills of Hackshall, Bro. & Co., at Richmond, Virginia.

MINE. The name given generally to every system of subterraneous work or excavation which has for its object the discovery and extraction of the metallic ores or other mineral produce. But in addition to the underground works which constitute the mine properly so called, the term usually comprehends also the ground on the surface, together with the numerous appendages which are required there; as steam-engines, water-wheels, and other machinery for drainage, the extraction of the ores, and their mechanical preparation, with various buildings and erections. The subject of mines is one of the most important within the whole range of human knowledge: their contents constitute the main-springs of civilization: and the means employed to obtain them are to be ranked among the most extraordinary instances of human enterprise, patience, and ingenuity. The art of mining has been practised from the earliest antiquity, and has formed a branch of industry to the most barbarous as well as the most civilized communities. It is true that we can scarcely dignify by the name of mining the operation by which the savage merely collects grains of gold in the sands of rivers, or extracts it by pounding, when mechanically combined with other substances; but even this simple operation becomes interesting

when viewed as the first link in the chain of those elaborate and scientific processes which result in placing at our disposal the metal of any ore, no matter how refractory.

In the lodes, or veins, the principal matters which fill them are to be distinguished from the accessory substances; the latter being distributed irregularly, amidst the mass of the first, in crystals, nodules, grains, seams, &c. The non-metalliferous exterior portion, which is often the largest, is called *gangue*, from the German *gang*, *vein*. The position of a vein is denoted, like that of the strata, by the angle of inclination, and the point of the horizon towards which they dip, whence the direction is deduced.

Veins are merely small lodes, which sometimes traverse the great ones, ramifying in various directions, and in different degrees of tenuity.

A metalliferous substance is said to be *disseminated*, when it is dispersed in crystals, spangles, scales, globules, &c., through a large mineral mass.

Certain ores which contain the metals most indispensable to human necessities, have been treasured up by the Creator in very bountiful deposites; constituting either great masses in rocks of different kinds, or distributed in lodes, veins, nests, concretions, or beds with stony and earthy admixtures; the whole of which become the objects of mineral exploration. These precious stores occur in different stages of the geological formations; but their main portion, after having existed abundantly in the several orders of the primary strata, suddenly cease to be found towards the middle of the secondary. Iron ores are the only ones which continue among the more modern deposites, even so high as the beds immediately beneath the chalk, when they also disappear, or exist merely as coloring matters of the tertiary earthy beds.

The strata of gneiss and mica-slate constitute in Europe the grand metallic domain. There is hardly any kind of ore which does not occur there in sufficient abundance to become the object of mining operations, and many are found nowhere else. The transition rocks, and the lower part of the secondary ones, are not so rich, neither do they contain the same variety of ores. But this order of things, which is presented by Great Britain, Germany, France, Sweden, and Norway, is far from forming a general law; since in equinoctial America the **gneiss is but little metalliferous; while** the superior strata, such as the clay-schists, the sienitic porphyries, the limestones, which complete the transition series, as also several secondary deposites, include the greater portion of the immense mineral wealth of that region of the globe.

All the substances of which the ordinary metals form the basis, are not equally abundant in nature; a great proportion of the numerous mineral species which figure in our classifications, are mere varieties scattered up and down in the cavities of the great masses or lodes. The workable ores are few in number, being mostly sulphurets, some oxides, and carbonates. These occasionally form of themselves very large masses, but more frequently they are blended with lumps of quartz, feldspar, and carbonate of lime, which form the main body of the deposit; as happens always in proper lodes. The ores in that case are arranged in small layers parallel to the strata of the formation, or in small veins which traverse the rock in all directions, or in nests or concretions stationed irregularly, or finally disseminated in hardly visible particles. These deposites sometimes contain apparently only one species of ore, sometimes several, which must be mined together, as they seem to be of contemporaneous formation; whilst, in other cases, they are separable, having been probably formed at different epochs.

The following general observations on the localities of ores, and on the indications of metallic mines, show their dispositions in various geological formations.

1. *Tin* exists principally in primitive rocks, appearing either in interlaced masses, in beds, or as a constituent part of the rock itself, and more rarely in distinct veins. Tin ore is found indeed sometimes in alluvial land, filling up low situations between lofty mountains.

2. *Gold* occurs either in beds or in veins, frequently in primitive rocks; though in other formations, and particularly in alluvial earth, it is also found. When this metal exists in the bosom of primitive rocks, it is particularly in schists; it is not found in serpentine, but it is met with in graywacke in Transylvania. The gold of alluvial districts, called gold of washing or transport, occurs, as well as alluvial tin, among the debris of the more ancient rocks.

3. *Silver* is found particularly in **veins**

and beds, in primitive and transition formations; though some veins of this metal occur in secondary strata. The rocks richest in it are gneiss, mica-slate, clay-slate, graywacke, and old alpine limestone. Localities of silver-ore itself are not numerous, at least in Europe, among secondary formations; but it occurs in combination with the ores of copper or of lead.

4. *Copper* exists in the three mineral epochas; first, in primitive rocks, principally in the state of pyritous copper, in beds, in masses, or in veins; second, in transition districts, sometimes in masses, sometimes in veins of copper pyrites; third, in secondary strata, especially in beds of cupreous schist.

5. *Lead* occurs also in each of the three mineral epochas; abounding particularly in primitive and transition grounds, where it usually constitutes veins, and occasionally beds of sulphuretted lead (galena). The same ore is found in strata or in veins among secondary rocks, associated now and then with ochreous iron-oxide and calamine (carbonate of zinc); and it is sometimes disseminated in grains through more recent strata.

6. *Iron* is met with in four different mineral eras, but in different ores. Among primitive rocks, magnetic iron ore and specular iron ore occur chiefly in beds, sometimes of enormous size; the ores of red or brown oxide of iron (hematite) are found generally in veins, or occasionally in masses with sparry iron, both in primitive and transition rocks; as also sometimes in secondary strata; but more frequently in the coal-measure strata, as beds of clay-ironstone, of globular iron, oxide, and carbonate of iron. In alluvial districts we find a cross clay-iron stone, granular iron-ore, bog-ore, swamp-ore, and meadow-ore. The iron ores which belong to the primitive period have almost always the metallic aspect, with a richness amounting even to 80 per cent. of iron, while the ores in the posterior formations become in general more and more earthy, down to those in alluvial soils, some of which present the appearance of a common stone, and afford not more than 20 per cent. of metal, though its quality is often excellent.

7. *Mercury* occurs principally among secondary strata, in disseminated masses, along with combustible substances; though the metal is met with occasionally in primitive countries.

8. *Cobalt* belongs to the three mineral epochas; its most abundant deposits are veins in primitive rocks; small veins containing this metal are found, however, in secondary strata.

9. *Antimony* occurs in veins or beds among primitive transition rocks.

10, 11. Bismuth and nickel do not appear to constitute the predominating substance of any mineral deposits; but they often accompany cobalt.

12. *Zinc* occurs in the three several formations: namely, as sulphuret or blende, particularly in primitive and transition rocks; as calamine, in secondary strata, usually along with oxide of iron, and sometimes with sulphuret of lead.

An acquaintance with the general results collected and classified by geology must be our first guide in the investigation of mines. This enables the observer to judge whether any particular district should, from the nature and arrangement of its rocks, be susceptible of including within its bosom, beds of workable ores; it indicates also, to a certain degree, what substances may probably be met with in a given series of rocks, and what locality these substances will preferably effect. For want of a knowledge of these facts, many persons have gone blindly into researches equally absurd and ruinous.

Formerly, indications of mines were taken from very unimportant circumstances; from thermal waters, the heat of which was gratuitously referred to the decomposition of pyrites; from mineral waters, whose course is however often from a far distant source; from vapors incumbent over particular mountain groups; from the snows melting faster in one mineral district than another; from the different species of forest trees, and from the greater or less vigor of vegetation, &c. In general, all such indications are equally fallacious with the divining rod, and the compass made of a lump of pyrites suspended by a thread.

Gunpowder is the most valuable agent of excavation; possessing a power which has no limit, and which can act every where, even under water. Its introduction, in 1615, caused a great revolution in the mining art. Gun-cotton is equally valuable.

It is employed in mines in different manners, and in different quantities, according to circumstances. In all cases, however, the process resolves itself into boring a hole, and enclosing a cartridge in it, which is afterwards made to explode. The hole is always cylindrical, and is usually made by means of the borer, a stem of iron, terminated by a blunt-edged chisel. It sometimes ends in a cross, formed by two chisels set transversely. The workman holds the stem in his left hand, and strikes it with an iron mallet held in his right. He is careful to turn the punch a very little round at every stroke. Several punches are employed in succession, to bore one hole; the first shorter, the latter ones longer, and somewhat thinner. The rubbish is withdrawn as it accumulates, at the bottom of the hole, by means of a picker, which is a small spoon or disk of iron fixed at the end of a slender iron rod. When holes of a large size are to be made, several men must be employed; one to hold the punch, and one or more to wield the iron mallet. The perforations are seldom less than an inch in diameter, and 18 inches deep; but they are sometimes two inches wide, with a depth of 50 inches.

The gunpowder, when used, is most commonly put up in paper cartridges. Into the side of the cartridge, a small cylindrical spindle or *piercer* is pushed. In this state the cartridge is forced down to the bottom of the hole, which is then stuffed, by means of the tamping bar, with bits of dry clay, or friable stones coarsely pounded. The piercer is now withdrawn, which leaves in its place a channel through which fire may be conveyed to the charge. This is executed either by pouring gunpowder into that passage, or by inserting into it reeds, straw stems, quills, or tubes of paper filled with gunpowder. This is exploded by a long match, which the workmen kindle, and then retire to a place of safety.

As the *piercer* must not only be slender but stiff, so as to be easily withdrawn when the hole is stamped, iron spindles are usually employed, though they occasionally give rise to sparks, and consequently to dangerous accidents, by their friction against the sides of the hole. Brass piercers have been sometimes tried; but they twist and break too readily.

Each hole bored in a mine, should be so placed in reference to the schistose structure of the rock, and to its natural fissures, as to attack and blow up the least resisting masses. Sometimes the rock is prepared beforehand for splitting in a certain direction, by means of a narrow channel excavated with the small hammer.

The quantity of gunpowder should be proportional to the depth of the hole, and the resistance of the rock, and merely sufficient to split it. Any thing additional would serve no other purpose than to throw the fragments about the mine, without increasing the useful effect. Into the holes of about an inch and a quarter diameter, and 18 inches deep, only two two ounces of gunpowder are put.

It appears that the effect of the gunpowder may be augmented by leaving an empty space above, in the middle of, or beneath the cartridge. In the mines of Silesia, the consumption of gunpowder has been eventually reduced, without diminishing the product of the blasts, by mixing sawdust with it, in certain proportions. The hole has also been filled up with sand in some cases, according to Mr. Jessop's plan, instead of being packed with stones, which has removed the danger of the tamping operation. The experiments made in this way have given results very advantageous in quarry blasts with great charges of gunpowder; but less favorable in the small charges employed in mines.

Water does not oppose an insurmountable obstacle to the employment of gunpowder; but when the hole cannot be made dry, a cartridge bag, impermeable to water, must be had recourse to, provided with a tube also impermeable, in which the *piercer* is placed.

After the explosion of each mining charge, wedgers and levers are employed, to drag away and break down what has been shattered.

Wherever the rock is tolerably hard, the use of gunpowder is more economical and more rapid than any tool-work, and is therefore always preferred. A gallery, for example, a yard and a half high, and a yard wide, the piercing of which by the hammer formerly cost from five to ten pounds sterling the running yard, in Germany, is executed at the present day by gunpowder at from two to three pounds. When, however, a precious mass of ore is to be detached, when the rock is cavernous, which nearly nullifies the action of gunpowder, or when there is reason to apprehend that the shock caused by the explosion may produce an injurious fall of rubbish, hand-tools alone must be employed.

When the rocks which cover valuable minerals are not of very great hardness, as happens generally with the coal formation, with pyritous and aluminous slates, sal gem, and some other minerals of the secondary strata, the *borer* is employed with advantage to ascertain their nature. This mode of investigation is economical, and gives, in such cases, a tolerably exact insight into the riches of the interior.

The mode of working mines is twofold; by *open excavations*, and *subterranean*.

Workings in the open air present few difficulties, and occasion little expense, unless when pushed to a great depth. They are always preferred for working deposits little distant from the surface; where, in fact, other methods cannot be resorted to, if the substance to be raised be covered with incoherent matters. The only rules to be observed are, to arrange the workings in terraces, so as to facilitate the cutting down of the earth; to transport the ores and the rubbish to their destination at the least possible expense, and to guard against the crumbling down of the sides. With the latter view, they ought to have a suitable slope; or to be propped by timbers whenever they are not quite solid.

Open workings are employed for valuable clays, sands, as also for the alluvial soils of diamonds, gold, and oxide of tin, bog iron ores, &c., limestones, gypsums, building stones, roofing slates, masses of rock-salt in some situations, and certain deposits of ores, particularly the specular iron of the island of Elba, the masses of stanniferous granite of *Gayer*, *Altenberg*, and *Seyffen*, in the Ertzgeberge, a chain of mountains between Saxony and Bohemia; the thick veins or masses of black oxide of iron of Nordmarch, Dannemora, &c., in Sweden; the mass of cupreous pyrites of Rœraas, near Drontheim in Norway; several mines of iron, copper, and gold in the Ural mountains, &c.

Subterranean workings may be conveniently divided into five classes, viz.:—

1. Veins or beds, much inclined to the horizon, having a thickness of at least two yards.

2. Beds of slight inclination, or nearly horizontal, the power or thickness of which does not exceed two yards.

3. Beds of great thickness, but slightly inclined.

4. Veins, or beds highly inclined, of great thickness.

5. Masses of considerable magnitude in all their dimensions.

Subterranean mining requires two very distinct classes of workings; the *preparatory*, and those for *extraction*.

The *preparatory* consist in galleries, or in pits and galleries destined to conduct the miner to the point most proper for attacking the deposit of ore, for tracing it all round this point, for preparing chambers of excavation, and for concerting measures with a view to the circulation of air, the discharge of waters, and the transport of the extracted minerals.

If the vein or bed in question be placed in a mountain, and if its direction forms a very obtuse angle with the line of the slope, the miner begins by opening in its side, at the lowest possible level, a gallery of elongation, which serves at once to give issue to the waters, to explore the deposit through a considerable extent, and then to follow it in another direction; but to commence the real mining operations, he pierces either shafts or galleries, according to the slope of the deposit, across the first gallery.

For a stratum little inclined to the horizon, placed beneath a plain, the first thing is to pierce two vertical shafts, which are usually made to arrive at two points in the same line of slope, and a gallery is driven to unite them. It is, in the first place, for the sake of circulation of air that these two pits are sunk; one of them, which is also destined for the drainage of the waters, should reach the lowest point of the intended workings.

The excavations of mines are divisible into three principal species; *shafts*, *galleries*, and *chambers*. When the width of these excavations is inconsiderable, as is commonly the case with shafts and galleries, their sides can sometimes stand upright of themselves; but more frequently they require to be propped or staved by billets of wood, or by walls built with bricks or stones; or even by stuffing the space with rubbish. These three kinds of *support* are called *timbering*, *walling*, and *filling* up.

Timbering is most used. It varies in form for the three species of excavations, according to the solidity of the walls which it is destined to sustain.

The timbering of shafts varies in form, as well as that of galleries, according to the nature and the locality of the ground which they traverse, and the purposes which they are meant to serve. The shafts intended to be stayed with timber are usually square or rectangular, because this form, in itself more convenient for the miner, renders the execution of the timbering more easy. The wood-work consists generally of rectangular frames, the spars of which are about eight inches in diameter, and placed at a distance asunder of from a yard to a yard and a half. The spars are never placed in contact, except when the pressure of the earth and the waters is very great. The pieces composing the frames are commonly united by a half-check, and the longer of the two pieces extends often beyond the angles, to be rested in the rock. Whether the shaft is vertical or inclined, the frame-work is always placed so that its plane may be perpendicular to the axis of the pit. It happens sometimes in inclined shafts that there are only two sides, or even a single one, which needs to be propped. These are stayed by means of cross beams, which rest at their two ends in the rock. When the frames do not touch one another, strong planks or stakes are fastened behind them to sustain the ground. To these planks the frames are firmly connected, so that they cannot slide. In this case the whole timbering will be supported, when the lower frame is solidly fixed, or when the pieces from above pass by its angles to be abutted upon the ground.

In the large rectangular shafts, which serve at once for extracting the ores, for the discharge of the waters, and the descent of the workmen, the spaces destined for these several purposes are in general separated by partitions, which also serve to increase the strength of the timberings, by acting as buttresses to the planks in the long sides of the frame-work.

When men penetrate by narrow passages into the interior of the earth, their respiration, joined to the combustion of candle and gunpowder, are not long in vitiating the air. The decomposition of wood contributes to the same effect, as also the mineral bed itself, especially in coal mines, by the carburetted hydrogen and carbonic acid evolved, and from the absorption of oxygen by pyrites. In many cases, arsenical and mercurial vapors are disengaged. Hence the necessity of maintaining in subterranean cavities a continual circulation of air, which may renew the atmosphere round the miners. The whole of the means employed to produce this effect, constitutes what is called the *ventilation of mines*.

These means are divided into *natural* and *artificial*. The *natural means* are the currents produced by the difference of density between the air of mines and the external air; the *artificial* are air-exhausters or condensers, fires, &c.

The temperature of the air of the subterranean workings surpasses the mean temperature of the place in which the mine is opened. Hence it is lighter in winter, but in summer often heavier than the air of the atmosphere. For this reason, when the mine presents two openings at different levels, the air naturally flows out by the most elevated in winter, and by the lowest in summer. We may take advantage of this circumstance, to lead the air into the bottom of even a very long gallery, opening into the side of the mountain, by piercing a shaft into its roof at some distance from the entrance, and dividing the gallery by a horizontal floor into two parts, which have no mutual communication, except at the furthest extremity—the upper part communicating with the shaft, and the under with the mouth of the gallery. If the two compartments have different dimensions, the air in the smaller sooner comes into an equilibrium of temperature with the rock; and the difference of temperature of the two compartments is sufficient to produce a current. If a streamlet of water flows through this gallery, it facilitates the flow of the air along the lower compartment. If a mine has several openings situated on the same level, it rarely happens but some peculiar circumstance destroys, during the colds of winter and the heats of summer, the equilibrium of the air. But in spring and autumn, when the external air is nearly of the same temperature with that of the mines, the above-named causes are almost always too feeble to excite an issuing current. The effect is, however, frequently obtained by raising over one of the shafts a chimney 20 or 30 yards high, which alone produces the effect of an opening at a different level. It has been remarked that stormy weather usually deranges every system of ventilation.

The chain of the Alleganies, which traverses the United States of North America from N.W. to S.E., includes a considerable number of deposits of iron, lead, and copper ores; along with some ores of silver, plumbago, and chromite of iron. Attempts have been made to mine a great many of these deposits, but most of these have been unsuccessful, and abandoned for a while. Some have been since re-opened.

A bed of black oxyde of iron occurs in gneiss near Franconia in New Hampshire. It has a power of from 5 to 8 feet; and has been mined through a length of 200 feet, and to a depth of 90 feet. The same ore is found in veins in Massachusetts and Vermont, accompanied by copper and iron pyrites. It is met with in immense quantities on the western bank of the lake Champlain, forming beds of from 1 to 20 feet in thickness, almost without mixture, encased in granite. It is also found in the mountains of that territory. These deposits appear to extend without interruption from Canada to the neighborhood of New-York, where an exploration on them may be seen at Crown Point. The ore there extracted is in much esteem. Several mines of the same species exist in New Jersey. The primitive mountains which rise in the north of this state near the Delaware, include a bed almost vertical of black oxide of iron, which has been worked to 100 feet in depth. In the county of Sussex the same ore occurs, accompanied with Franklinite. At New Milford, in Connecticut, a pretty abundant mine of sparry iron occurs; the only one of the kind known in the Alleganics. The United States contain a great many iron works, some of which prior to the year 1773, sent over iron to London. They are principally supplied from alluvial iron ore. Under the article Iron, various localities of the ores have been cited.

The most remarkable lead mines of the Alleganies are those of Southampton, in Massachusetts, and of Perkiomen creek, in Pennsylvania, 8 leagues from Philadelphia. The first furnishes a galena, slightly argentiferous; an ore accompanied with various minerals, with base of lead, copper, and zinc, and with *gangues* (vein-stones) of quartz, sulphate of baryta, and fluor spar. These substances form a vein which traverses several primitive rocks, and is said to be known over a length of more than 6 leagues. At Perkiomen creek a vein of galena is mined which traverses a sandstone, referred by many geologists to the old red sandstone. Along with galena a great variety of minerals is found with a basis of lead, zinc, copper, and iron. The mines of lead worked in Virginia, on the banks of the Kanahwa, deserve also to be mentioned. Under the articles Galena and Lead notice has been made of the other deposits of lead in the United States.

None of the copper mines actually in operation in the United States seem to merit particular attention. The mine of Schuyler, in New Jersey, had excited high hopes, but after the workings had been pushed to a depth of 300 feet, they have been for some years abandoned. The ore, which consisted of sulphuret of copper, with oxide and carbonate of copper, occurred in a red sandstone. No reference is made here to the extensive native copper deposits of Lake Superior.

In some points of the Alleganies, deposits have been noticed of chromite of iron and graphite.—See Chrome.

Coal-measures occur in several points of the United States, especially on the N.W. slope of the Allegany mountains, in Michigan, Ohio, and Missouri.

MINERALS comprehend all the solid matters of the earth, not vegetable or animal; for, though these last are in substance mineral, yet their organization and phenomena separate them from the simple mineral. In like manner, though the gases and acids may be generated from minerals, and, again perhaps concentrated into minerals, yet they are not in a just sense to be regarded as minerals.

The system of Mohs includes these as two genera, and adds a third in water. Logic thus confounds nature. As a summary, we will subjoin his orders strictly mineral, as a brief exhibition of similar substances.

Salt Order.—Genera. 1. Natron. 2. Glauber. 3. Nitre. 4. Rock. 5. Ammoniac. 6. Vitriol. 7. Epsom. 8. Alum. 9. Borax. 10. Brythine.

Haloide Order.—Genera. 1. Gypsum. 2. Cryone. 3. Alum. 4. Fluor. 5. Calc.

Baryte Order.—Genera. 1. Parachrose. 2. Zinc. 3. Scheelium. 4. Hal. 5. Lead.

Malachite Order.—Genera. 1. Staphyline. 2. Lirocone. 3. Olive. 4. Azure. 5. Emerald. 6. Habroneme.

Mica Order.—Genera. 1. Euchlore. 2. Cobalt. 3. Iron. 4. Graphite. 5. Talc. 6. Pearl.

Spar Order.—Genera. 1. Schiller. 2. Disthene. 3. Triphane. 4. Dystome. 5. Kouphone. 6. Petaline. 7. Feldspar. 8. Augite. 9. Azure.

Gem Order.—Genera. 1. Andalusite. 2. Corundum. 3. Diamond. 4. Topaz. 5. Emerald. 6. Quartz. 7. Aximite. 8. Chrysolite. 9. Boracite. 10. Tourmaline. 11. Garnet. 12. Zircon. 13. Gadolinite.

Ore Order.—Genera. 1. Titanium. 2. Zinc. 3. Copper. 4. Tin. 5. Scheelium. 6. Tantalum. 7. Uranium. 8. Cerium. 9. Chrome. 10. Iron. 11. Manganese.

Metal Order.—Genera. 1. Arsenic. 2. Tellurium. 3. Antimony. 4. Bismuth. 5. Mercury. 6. Silver. 7. Gold. 8. Platina. 9. Iron. 10. Copper.

Pyrites Order.—Genera. 1. Nickel. 2. Arsenic. 3. Cobalt. 4. Iron. 5. Copper.

Glance Order.—Genera. 1. Copper. 2. Silver. 3. Lead. 4. Tellerium. 5.

Molybdenum. 6. Bismuth. 7. Antimony. 8. Melane.

Blende Order.—Genera. 1. Glance. 2. Garnet. 3. Purple. 4. Ruby.

He then makes *sulphur*, *resin*, and *mineral coal* separate orders.

Hardness in minerals is expressed by the figures 1 to 10, with the letter H.

1	is as	Talc.
2	..	Gypsum.
3	..	Calcareous Spar.
4	..	Fluor Spar.
5	..	Apatite.
6	..	Feldspar.
7	..	Quartz.
8	..	Topaz.
9	..	Corundun.
10	..	Diamond.

The study of mineralogy has made great progress in this country within the last thirty years: almost all the known species have been found and described on this continent, and several new species have been added to the list. The most approved work on this science with its reference to this continent, is that of Mr. Dana.

Mineral Waters, are those waters which contain such a proportion of foreign matter as to render them unfit for common use, and give them a sensible flavor and a specific action upon the animal economy. They are commonly divided into four classes: acidulous or carbonated, saline, chalybeate or ferruginous, and sulphureous. In regard to temperature they are divided into warm and cold. The substances found in mineral waters are numerous: the most frequent being nitrogen, oxygen, sulphur, and carbon, lime, iron, and magnesia. Artificial waters are now made to represent the natural springs, and are equally efficacious as medical agents: so that there are natural and artificial mineral waters. The saline springs are composed of salts of soda and lime, or occasionally magnesia replacing the soda with excess of carbonic acid, and oxide of iron. The chief are those of Pyrmont, Seidlitz, and Epsom. The ferruginous waters have a styptic taste, and are turned black by infusion of nut-galls; sometimes the iron exists in the water as an oxide dissolved by carbonic acid, sometimes as a sulphate, and sometimes in both conditions together. Such are the waters of Vichy, Forges, Passy, Spa, Cheltenham, and Tunbridge: Bedford, Pittsburgh, Yellow Springs in Ohio, Virginia, and Pennsylvania belong also to this class. Acidulous waters have an acid taste and extricate carbonic acid, of which they contain five or six times their volume. They contain carbonates and chlorides of magnesia and lime, carbonate and sulphate of iron; such are the waters of Bath, Buxton, Bristol, Vichy, Seltzer, New Lebanon, &c. They are acidulous. The sulphuretted waters are easily known by their smell and their tarnishing silver and copper: such are those of Harrowgate, Moffat, Aix la Chapelle, Saratoga and Ballston.

MINIUM. This pigment is a peculiar oxyde of lead, consisting of two atoms of the protoxyde and one of the peroxyde; but, as found in commerce, it always contains a little extra protoxyde, or yellow massicot. It is prepared by calcining lead upon a reverberatory hearth with a slow fire, and frequent renewal of the surface with a rake, till it becomes an oxyde, taking care not to fuse it. The calcined mass is triturated into a fine powder in a paint mill, where it is elutriated with a stream of water, to carry off the finely levigated particles, and to deposit them afterwards in tanks. The powder thus obtained, being dried, is called massicot. It is converted into minium, by being put in quantities of about 50 pounds into iron trays, 1 foot square, and 4 or 5 inches deep. These are piled up upon the reverberatory hearth, and exposed during the night, for economy of fuel, to the residuary heat of the furnace, whereby the massicot absorbs more oxygen, and becomes partially red lead. This, after being stirred about, and subjected to a similar low calcining heat once and again, will be found to form a marketable red lead.

The best minium, however, called *orange mine*, is made by the slow calcination of good white lead (carbonate) in iron trays. If the lead contains either iron or copper, it affords a minium which cannot be employed with advantage in the manufacture of flint-glass for pottery glazes, or for house-painting.

Dumas found several samples of red lead which he examined to consist of the chemical sesquioxyde, and the protoxyde, in proportions varying from 50 of the former and 50 of the latter, to 95·3 of the former and 4·7 of the latter. The more oxygen gas it gives out when heated, the better it is, generally speaking.

MIRROR. A speculum or looking-glass, or any other polished body capable of reflecting the images of objects, rays of light from which fall upon them. Silver is considered to be the most powerful reflector; but the speculum metal, as now prepared, is scarcely inferior, if at all so, and in some cases even better. In the very early ages of the world, polished metallic specula were employed as mirrors by the Jewish and Egyptian women, especially of brass; but in modern times, quicksilver plates of glass are alone used as mirrors.

Concave Mirrors are used to concentrate the rays of the sun in a single point, and thereby produce intense heat. The surfaces formed by the revolution of the ellipse, parabola, and hyperbola, are such as reflect them accurately to one point; provided they emanate from one point, are parallel to one another (as the solar rays), or would converge to a more remote point than it is desirable to use. The great difficulty of constructing these has led to the employment of spherical segments, which, though not accurate, yet, under proper restrictions, are approximately so.

MISPICKEL. Arsenical pyrites.

MODEL, in sculpture, figures made in wax, terra cotta, or other plastic material, which the artist moulds to guide him in his work; in the same way as the painter makes a sketch, or the artist a design. When a model of any object is to be taken, the object should first be greased so as to prevent the plaster from sticking to it, and then be placed on a smooth table previously oiled or covered with cloth; the original is then surrounded with a frame or raised margin of putty or card at such a distance as to allow of the plaster resting on the table on every side of the subject, as wide as may be thought necessary for the strength of the object. The plaster is then poured on as uniformly as possible over the whole substance. until it is every where covered to desirable thickness. It is then allowed to settle till the plaster has become cool and hardened; the frame is then removed and the mould inverted, and subject taken out of it: when the plaster is thoroughly dry it should be seasoned.

MOHAIR. The hair of a variety of the common goat, famous for being soft and fine as silk, and of a silvery whiteness. It is not produced anywhere but in the vicinity of Angora, in Asia Minor. The exportation of this valuable and beautiful article, unless in the shape of yarn, was formerly prohibited; but it may now be exported unspun. The production, preparation, and sale of mohair have long engrossed the principal attention of the inhabitants of Angora; and it used to form an important article of Venetian commerce. It is manufactured into camlets and other expensive stuffs. Hitherto but little has been imported into England or this country.

MOIREE METALLIQUE, called also crystalline tin plate, is a primrose appearance, produced upon the surface of tin plate by exposing it to the vapor of, or washing it over with, dilute nitromuriatic acid, rinsing with water, and then covering with lacker. The plate treated in this way has a beautiful and variegated appearance.

MONOCHROMATIC LAMP. When a solution of common salt is added to spirit of wine, the mixture burns with a flame in which yellow predominates almost to the exclusion of the other colored rays; the consequence is, that objects viewed by this light are all either yellow or black, and deficient in the tints which they exhibit when seen by solar light, or by that of our ordinary combustibles.

MOLYBDENUM, is a rare metal, which occurs in nature sometimes as a sulphuret, sometimes as molybdic acid, and at others as molybdate of lead. Its reduction from the acid state by charcoal requires a very high heat, and affords not very satisfactory results. When reduced by passing hydrogen over the ignited acid, it appears as an ash-gray powder, susceptible of acquiring metallic lustre by being rubbed with a steel burnisher; when reduced and fused with charcoal, it possesses a silver white color, is very brilliant, hard, brittle, of specific gravity 8·6; it melts in a powerful air-furnace, oxydizes with heat and air, burns at an intense heat into molybdic acid, dissolves in neither dilute sulphuric, muriatic, nor fluoric acids, but in the concentrated sulphuric and nitric.

The protoxyde consists of 85·69 of metal, and 14·31 of oxygen; the deutoxyde consists of 75 of metal, and 25 of oxygen; and the peroxyde, or molybdic acid, of 66·6 of metal, and 33·4 of oxygen. These substances are too rare at present to be used in any manufacture.

Molybdic acid when united with ammonia, forming the molybdate of ammonia, is now employed as the most delicate chemical test for the presence of phosphoric acid. It is the most delicate means of detecting the presence of the latter substance.

MORDANT, in dying and calico-printing, denotes a body which, having a two-fold attraction for organic fibres and coloring particles, serves as a bond of union between them, and thus gives fixity to dyes; or it signifies a substance which, by combining with coloring particles in the pores of textile filaments, renders them insoluble in hot soapy and weak alkaline solutions. In order properly to appreciate the utility and the true functions of mordants, we must bear in mind that coloring matters are peculiar compounds possessed of certain affinities, their distinctive characters being not to be either acid or alkaline, and yet to be capable of combining with many bodies, and especially with salifiable bases, and of receiving from each of them modifications in their color, solubility, and alterability. Organic coloring substances, when pure, have a very energetic attraction for certain bodies, feeble for others, and none at all for some. Among these immediate products of animal or vegetable life, some are soluble in pure water, and others become so only through peculiar agents. We may thus readily conceive, that whenever a dye-stuff possesses a certain affinity for the organic fibre, it will be able to become fixed on it, or to dye it without the intervention of mordants, if it be insoluble by itself in water, which, in fact, is the case with the coloring matters of safflower, annotto, and indigo. The first two are soluble in alkalis; hence, in order to use them, they need only be dissolved in a weak alkaline ley, be thus applied to the stuffs, and then have their tinctorial substance precipitated within their pores, by abstracting their solvent alkali with an acid. The coloring matter, at the instant of ceasing to be liquid, is in an extremely divided state, and is in contact with the organic fibres for which it has a certain affinity. It therefore unites with them, and, being naturally insoluble in water, that is, having no affinity for this vehicle, the subsequent washings have no effect upon the dye. The same thing may be said of indigo, although its solubility in the dye-bath does not depend upon a similar cause, but is due to a modification of its constituent elements, in consequence of which it becomes soluble in alkalis. Stuffs plunged into this indigo bath get impregnated with the solution, so that when again exposed to the air, the dyeing substance resumes at once its primitive color and insolubility, and washing can carry off only the portions in excess above the intimate combination, or which are merely deposited upon the surface of the stuff.

Such is the result with insoluble coloring matters: but for those which are soluble it should be quite the reverse, since they do not possess an affinity for the organic fibres, which can counterbalance their affinity for water. In such circumstances, the dyer must have recourse to intermediate bodies, which add their affinity for the coloring matter to that possessed by the particles of the stuff, and increase by this two-fold action the intimacy and the stability of the combination. These intermediate bodies are the true *mordants*.

Mordants are in general found among the metallic bases or oxydes; whence they might be supposed to be very numerous, like the metals; but as they must unite the two-fold condition of possessing a strong affinity for both the coloring matter and the organic fibre, and as the insoluble bases are almost the only ones fit to form insoluble combinations, we may thus perceive that their number may be very limited. It is well known, that although lime and magnesia, for example, have a considerable affinity for coloring particles, and form insoluble compounds with them, yet they cannot be employed as mordants, because they possess no affinity for the textile fibres.

Experience has proved, that of all the bases, those which succeed best as mordants are alumina, tin, and oxyde of iron; the first two of which, being naturally white, are the only ones which can be employed for preserving to the color its original tint, at least without much variation. But, whenever the mordant is itself colored, it will cause the dye to take a compound color quite different from its own. If, as is usually said, the mordant enters into a real chemical union with the stuff to be dyed, the application of the mordant should obviously be made in such circumstances as are known to be most favorable to the combination taking place; and this is the principle of every day's practice in the dye-house.

Mordant is also the name sometimes given to the adhesive matter by which gold-leaf is made to adhere to surfaces of wood and metal in gilding. Paper, vellum, taffety, &c., are easily gilt by the aid of different mordants, such as the following: 1, beer in which some honey and gum arabic have been dissolved; 2, gum arabic, sugar, and water; 3, the viscid juice of onion or hyacinth, strengthened with a little gum arabic. When too much gum is employed, the silver or gold is apt to crack in the drying of the mordant. A little carmine should be mixed with the above colorless liquids, to mark the places where they are applied. The foil is applied by means of a dossil of cotton wool, and when the mordant has become hard, the foil is polished with the same.

The best medium for sticking gold and silver leaf to wood is the following, called *mixtion* by the French artists:—1 pound of amber is to be fused, with 4 ounces of mastic in tears, and 1 ounce of Jewish pitch, and the whole dissolved in 1 pound of linseed oil rendered drying by litharge.

The above is used by distemper painters and paper-hanging manufacturers for attaching gold and silver leaf to walls or paper.

MORPHIA. To obtain this substance from opium, free from narcotine:—Evaporate to the consistence of an extract a spiritous solution of opium; then, by successive solutions and filtrations, separate all the resinous matter of the extract, which separates the narcotine from the morphia: long ebullition with calcined magnesia, a series of filtrations, and washings and dryings, yield very pure morphia, free from narcotine. When the resinous matter is dissolved in dilute sulphuric acid, and the solution decomposed by potash, the narcotine is precipitated, which is purified by a fresh solution in sulphuric acid and precipitation by ammonia, and this often, after filtration, washing, and re-dissolving in alcohol of 0·903, crystallizes. A pound of opium yields, by this process, 8 drs. of perfectly pure white crystallized morphia; or it may be obtained by frequently digesting opium in muriatic acid, adding sea salt, and saturating with ammonia. Wash the precipitate, and redissolve in acid, filter, and cool. The muriate of morphia will crystallize, and may be separated in blotting paper. Wash with pure ammonia to decompose the muriate, dry and dissolve in alcohol, and finally crystallize. The muriate and sulphate are the two chief preparations.

MORTAR is a cement, made by expelling, by fire, the carbonic acid of carbonate of lime, or limestone, and mixing water with sand, or ashes, as a paste. Then, as the acid speedily recombines with this hydrate of lime, the mortar sets as limestone again, and increases in hardness with age. Mortar is often used of two qualities, or proportions of sand—the greater for inside joints, and the less for outside; in which the sand-mortar, for pointing, is often mixed; is finer, also, with forge-ashes, but white cement is also used.

Mortar, for paving, is improved by mixing the residuum of the distillation of aquafortis.

MORTAR, HYDRAULIC, called also *Roman Cement*, is the kind of mortar used for building piers, or walls under or exposed to water, such as those of harbors, docks, &c. The poorer sorts of limestone are best adapted for this purpose, such as contain from 8 to 25 per cent. of foreign matter, in silica, alumina, magnesia, &c. These, though calcined, do not slake when moistened; but if pulverized they absorb water without swelling up or heating, like *fat* lime, and afford a paste which hardens in a few days under water, but in the air they never acquire much solidity. Smeaton first discovered these remarkable facts, and described them in 1759.

The following analyses of different hydraulic limestones, by Berthier, merit confidence:

A. *Analyses of limestones.*	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Carbonate of lime............	97·0	98·5	74·5	76·5	80·0
Carbonate of magnesia.......	2·0	....	23·0	3·0	1·5
Carbonate of protoxide of iron	....	....	....	3·0	....
Carbonate of manganese.....	....	....	....	1·5	....
Silica and alumina..........				15·2	18·0
Oxyde of Iron..............	1·0	1·5	1·2		
	100·0	100·0	100·0	100·0	100·0

All good hydraulic mortars must contain alumina and silica; the oxides of iron and manganese, at one time considered essential, are rather prejudicial ingredients. By adding silica and alumina, or merely the former, in certain circumstances, to fat lime, a water-cement may be artificially formed; as also by adding to lime any of the following native productions, which contain silicates; puzzolana, trass or tarrass, pumice-stone, basalt-tuff, slate-clay. Puzzolana is a volcanic product, which forms hills of considerable extent to the south-west of the Apennines, in the district of Rome, the Pontine marshes, Viterbo, Bolsena, and in the Neapolitan region of Puzzuolo, whence the name. A similar volcanic tufa is found in many other parts of the world. According to Berthier, the Italian puzzolana consists of 44·5 silica; 15·0 alumina; 8·8 lime; 4·7 magnesia; 1·4 potash; 4·1 soda; 12 oxydes of iron and titanium; 9·2 water; in 100 parts.

The *tufa* stone, which, when ground, forms *trass*, is composed of 57·0 silica, 16·0 clay, 2·6 lime, 1·0 magnesia, 7·0 potash, 1·0 soda, 5 oxides of iron and titanium, 9·6 water. This tuff is found abundantly filling up valleys in beds of 10 or 20 feet deep, in the north of Ireland, among the schistose formations upon the banks of the Rhine, and at Manheim in Bavaria.

The fatter the lime, the less of it must be added to the ground puzzolana or trass, to form a hydraulic mortar; the mixture should be made extemporaneously, and must at any rate be kept dry till about to be applied. Sometimes a proportion of common sand mortar instead of lime is mixed with the trass. When the hydraulic cement hardens too soon, as in 12 hours, it is apt to crack; it is better when it takes 8 days to concrete. Through the agency of the water, silicates of lime, alumina (magnesia), and oxyde of iron are formed, which assume a stony hardness.

In England the stones are calcined in shaft-kilns, or sometimes in mound-kilns, then ground, sifted, and packed in casks. The color of the powder is dark-brown red. When made into a thick paste with water, it absorbs little of it, evolves hardly any heat, and soon indurates. It is mixed with sharp sand in various proportions, immediately before using it; and is employed in all marine and river embankments, for securing the seams of stone or brick floors or arches from the percolation of moisture, and also for facing walls to protect them from damp.

The cement of Pouilly is prepared from a Jurassic (secondary) limestone, which contains 39 per cent. of silica, with alumina, magnesia, and iron oxide. Vicat forms a factitious Roman cement by making bricks with a pasty mixture of 4 parts of chalk, and 1 part of dry clay, drying, burning, and grinding them. River sand must be added to this powder; and even with this addition, its efficacy is somewhat doubtful; though it has, for want of a better substitute, been much employed at Paris.

The cement of Dihl consists of porcelain or salt-glaze potsherds ground fine, and mixed with boiled linseed oil.

All sorts of lime are made hydraulic, in the humid way, by mixing slaked lime with solutions of common alum or sulphate of alumina; but the best method consists in employing a solution of the silicate of potash, called liquor of flints, or soluble glass, to mix in with the lime, or lime and clay. A hydraulic cement may also be made which will serve for the manufacture of architectural ornaments, by making a paste of pulverized chalk, with a solution of the silicate of potash. The said liquor of flints will likewise give chalk and plaster a stony hardness, by merely soaking them in it after they are cut or moulded to a proper shape. On exposure to the air, they get progressively indurated. Superficial hardness may be readily procured by washing over the surface of chalk, &c., with liquor of flints, by means of a brush. This method affords an easy and elegant method of giving a stony crust to plastered walls and ceilings of apartments; as also to statues and busts, cast in gypsum, mixed with chalk.

The essential constituents of every good hydraulic mortar, are caustic lime and silica; and the hardening of this compound under water consists mainly in a chemical combination of these two constituents through the agency of the water, producing a hydrated silicate of lime. But such mortars may contain other bases besides lime, as for example clay and magnesia, whence double silicates of great solidity are formed; on which account dolomite is a good ingredient of these mortars. But the silica must be in a peculiar state for these purposes; namely, capable of affording a gelatinous paste with acids; and if not so already, it must be brought into this condition, by calcining it along with an alkali or an alkaline earth, at a bright red heat, when it will dissolve, and gelatinize in acids. Quartzose sand, however fine its powder may be, will form no mortar with lime; but if the powder be ignited with the lime, it then becomes fit for hydraulic work. Ground felspar or clay forms with slaked lime no water cement; but when they are previously calcined along with the lime, the mixture becomes capable of hardening under water.

The *mastic* called *Hamelin's*, and so much employed in London, is composed of ground Portland stone (roe stone), sand, and litharge, in the proportion of 62 of the first, 35 of the second, and 3 of the third, in 100 parts; but other proportions will also answer the purpose. Chalk will not make a good mastic, being too compact to permit the air to insinuate between the pores, and to produce the concretion of the linseed oil, with which the above mixture is worked up and applied. This mastic soon acquires great hardness, and is totally impervious to water. The surface to which it is to be applied must be dry, and smeared over with linseed oil. Considerable dexterity is required to make good work with it. The fine dust of sandstone alone, mixed with 10 or 12 per cent. of litharge, and 7 per of linseed oil, forms an excellent mastic.

Limestone, which contains so much as 10 per cent. of clay, comports itself after calcination, if all the carbonic acid be expelled, just as pure limestone would do. When it is less strongly burned, it affords, however, a mass which hardens pretty speedily in water. If the argillaceous proportion of a marl amounts to 18 or 20 per cent., it still will slake with water, but it will absorb less of it, and forms a tolerably good hydraulic mortar, especially if a little good Roman cement be added to it. When the proportion of clay is 25 or 30 per cent. after burning, it heats but little with water, nor does it slake well, and must therefore be ground by stampers or an edge millstone, when it is to be used as a mortar. This kind of marl yields commonly the best water cement without other addition. Should the quantity of clay be increased further, as up to 40 per cent., the compound will not bear a high or long-continued heat without being spoiled for making hydraulic mortar after grinding to powder. When more strongly calcined, it forms a vitriform substance, and should, after being pulverized, be mixed up with good lime, to make a water mortar.

The *Manlius* or water limestones of the New-York system of rocks, furnishes in some of its courses, when quarried, a very good water cement, but the composition of the stone varies in different places. Some of this rock, taken from South Fayette, Seneca Co., N. Y., afforded to the Editor, on treatment by muriatic acid, the following composition:

Soluble in muriatic acid—	
Silica	**4·0**
Alumina	**4·5**
Oxide of Iron	**·5**
Carbonate of Lime	**15·0**
Magnesia	**11·0**
Oxide of Manganese	**2·0**
	87·0
Insoluble in acid—	
Silicates of Alumina and Iron	**68·0**
	100·0

There was apparently in this stone too much silica, and too small a proportion of lime, to make a good hydraulic stone.

MOSAIC GOLD. For the composition of this peculiar alloy of copper and zinc, called also *Or-molu*, Messrs. Parker and Hamilton obtained a patent in November, 1825. Equal quantities of copper and zinc are to be "melted at the lowest temperature that copper will fuse," which being stirred together so as to produce a perfect admixture of the metals, a further quantity of zinc is added in small portions, until the alloy in the melting-pot becomes of the color required. If the temperature of the copper be too high, a portion of the zinc will fly off in vapor, and the result will be merely spelter or hard solder; but if the operation be carried on at as low a heat as possible, the alloy will assume first a brassy yellow color; then, by the introduction of small portions of zinc, it will take a purple or violet hue, and will ultimately become perfectly white; which is the appearance of the proper compound in its fused state. This alloy may be poured into ingots; but as it is difficult to preserve its character when re-melted, it should be cast directly into the figured moulds. The patentees claim the exclusive right of compounding a metal consisting of from 52 to 55 parts of zinc out of 100.

Mosaic gold, the *aurum musivum* of the old chemists, is a sulphuret of tin.

MOSAIC. There are several kinds of mosaic, but all of them consist in imbedding fragments of different colored substances, usually glass or stones, in a cement, so as to produce the effect of a picture. The beautiful chapel of Saint Lawrence in Florence, which contains the tombs of the Medici, has been greatly admired by artists, on account of the vast multitude of precious marbles, jaspars, agates, avanturines, malachites, &c., applied in mosaic upon its walls. The detailed discussion of this subject belongs to a treatise upon the fine arts.

The latest improvement in Mosaic art has been effected by Mr. Prosser, of Birmingham, England, in 1840, who found that if the material of porcelain (a mixture of flint and fine clay) be reduced to a dry powder, and in that subjected to strong pressure between steel dyes, the powder is compressed into one fourth of its bulk, and is converted into a compact substance of great hardness and density; much less porous, and much harder than common porcelain, uncompressed and baked in the furnace. This discovery was first applied to the manufacture of buttons by Mr. Prosser, and Mr. Blashfield applied it to the formation of tesseræ. He obtained cubes thus formed, and by the application of these in any forms, as squares for tersillation, triangles and hexagons, to imitate the opus Alexandrinum, polygons, and rhomboids, or of any color, and by enamelling the surface with the most brilliant tints and gold, very good substitutes for the ancient glass mosaic were produced. They are cemented together in a pattern form on a table previously, and when hard may be laid down on the required spot.

MOTHER OF PEARL is the hard, silvery, brilliant internal layer of several kinds of shells, particularly oysters, which is often variegated with changing purple and azure colors. The large oysters of the Indian seas alone secrete this coat of sufficient thickness to render their shells available to the purposes of manufactures. The genus of shell-fish called *Pentadinæ* furnishes the finest pearls, as well as mother of pearl; it is found in greater perfection round the coast of Ceylon, near Ormus in the Persian Gulf, at Cape Comorin, and among some of the Australian seas. The brilliant hues of mother of pearl do not depend upon the nature of the substance, but upon its structure. The microscopic wrinkles or furrows which run across the surface of every slice act upon the reflected light in such a way as to produce the chromatic effect; for Sir David Brewster has shown, that if we take, with very fine black wax, or with the fusible alloy of D'Arcet, an impression of mother of pearl, it will possess the iridescent appearance. Mother of pearl is very delicate to work; but it may be fashioned by saws, files, and drills, with the aid sometimes of a corrosive acid, such as the dilute sulphuric or muriatic; and it is polished by colcothar of vitriol.

MOTHER WATER. A term applied by chemists to saline solutions from which crystals have been deposited, and which, when poured off and re-evaporated, furnish a second crop.

MOTION. In mechanical philosophy, motion is the change of place; that is, of the part of space which the body occupies, or in which it is extended. Motion is *real* or *absolute* when the moving body changes its place in absolute space; it is *relative* when the body changes its place only with relation to surrounding bodies; and it is *apparent* when the body changes its situation with respect to other bodies that appear to us to be at rest. All the phenomena of motion are derived by mathematical deductions from the three following laws of motion of Newton:

1. A body must continue for ever in a state of rest, or of uniform motion in a straight line, if it be not disturbed by the action of an external cause.

2. Every change of motion produced by any external force is proportional to the force impressed, and in the direction of the straight line in which the force acts.

3. Action and reaction are equal and in contrary directions; that is, equal and contrary changes of motion are produced on bodies which mutually act on each other.

MOULDINGS, in architecture, are the annular, the astragal or bead, the ogee, the cuna recta, the cavetto or hollow, the ovolo, the scotia, and the torus.

MOULDINESS may be retarded by the presence of aromatics. It is a plant propagated by seeds.

MOUNTAIN SOAP is a tender mineral, soft to the touch, which assumes a greasy lustre when rubbed, and falls to pieces in water. It consists of silica 44, alumina 26·5, water 20·5, oxide of iron 8, lime 0·5. It occurs in beds, alternating with different sorts of clay, in the Isle of Skye, at Billin in Bohemia, &c. It has been often, but improperly, confounded with steatite.

MUCIC ACID is the same as the saclactic acid of Scheele, and may be obtained by digesting one part of gum arabic, sugar of milk, or pectic acid, with twice or thrice their weight of nitric acid. It forms white granular crystals, and has not been applied to any use in the arts.

MUCILAGES are gummy solutions, in water, of lacacia, gum arabic, tragacinth, and starch. They are also common animal and vegetable fluids.

MUDARINE. The root of the mudar or mudhar plant, the *calotropis mudarii*, of Hamilton, belonging to the *asclepiadeæ*, well known in the East as a powerful medicine. The most remarkable peculiarity of mudarine is, that its solubility in water diminishes as the temperature increases. A concentrated solution, which is perfectly transparent and fluid at 50°, has its transparency diminished, and gelatinizes at a little above 70°. On being allowed to cool, the jelly melts, and regains its former fluidity. If the temperature be raised considerably above 70°, the jelly contracts and separates from a liquid, and it has lost its power of resuming its liquid state on reduction of temperature.

MUFFLE is the name of a system of double pulleys, moved together with parallel cords, the power of which is as the number of cords at the lower block. It is also a portable oven or furnace.

MULBERRY, a very important genus of trees, *morus*, allied to the nettle, and belonging to the natural family *urticea*, whose fruit yields tartaric acid, and is edible, its leaves silk, its bark paper and useful wood. The black species produce the best fruit, the white, such leaves as silk-worms prefer, and in which the fibrous tissue is visible; and the paper species, of whose fibrous bark cloth is made in the South Sea Islands, and paper in Japan. It grows 40 feet high, and the trunk about 2 feet in diameter. It is naturalized now in Europe.

The quickest and most certain mode of raising the mulberry-tree is, from cutting the old branches. Take a branch in the month of March, eight or nine feet in length, plant it half its length in any good soil, and it will produce fruit the following year. But the most approved mode of cultivation is from seed.

In this country the white mulberry flourishes from the 43d to the 32d degree of latitude. The leaves of the black mulberry are sometimes substituted for food for silk-worms. The *morus rubra*, or red mulberry, is a native of the United States, and is valuable on account of the properties of the wood. It is abundant on the Ohio, its tributaries, and lower part of the Missouri; the wood is fine-grained, compact, and solid. It is employed in ship-building at Baltimore and Philadelphia, for the upper and lower parts of the frame, for the knees and floor timbers, and for tree-nails. It is not inferior to the locust-wood. The leaves do not appear fit for silk-worms.

MULE, in manufactures, is a machine, invented by Crompton, in 1799, for producing finer yarn, and has now quite superseded the jenny. For producing threads of the finest kind, a process is necessary which is called stretching, and analogous to that which is performed with carded cotton upon a common spinning-wheel. The spindles are mounted upon a carriage, which is moved backwards and forwards across the floor, receding when the threads are to be stretched, and returning when they are to be wound up. The yarn produced by mule-spinning is employed in the fabrication of the finest articles, and threads have been produced of such fineness, that a pound of cotton has been extended to 300 hanks, or 167 miles.

MULLER is the name of a stone for grinding colors, usually flat, and worked with the hand, or with a horse and a wheel. But a concave muller has been invented, which, being placed vertically, and the concavity supplied with rough color, it is pressed and worked by another stone, worked with a winch or power. The muller is a segment of the turning-stone.

MULTUM (*for brewers, instead of malt and hops*). To each quart of extract of quassia add 40 oz. of liquorice root.

MUNDIC. A name given to copper pyrites. It was comparatively useless until lately, when it was introduced into the manufacture of soda-ash, from a knowledge of the fact of its ready conversion, by heat and an alkali, into a sulphate of the alkali and peroxide of iron. The sulphuric acid being thus produced by the oxygen of the air alone, sulphur ores, hitherto valueless, are thus rendered more valuable. Since the introduction of this process, chlorine has been obtained by causing the oxygen of the air to act on the chloride of iron, oxidising the iron and setting the chlorine free. The cost of making soda is reduced by this process, and thus soap, soda, and glass, can be had on cheaper terms. It consists of copper 30, sulphur 37, iron 33, in 100 parts.

MURIACITE. An anhydrous sulphate of lime, containing a little common salt.

MURIATIC ACID, or HYDROCHLORIC ACID. This acid was originally discovered by Glauber, and called by him *spirit of salt*. In its pure or gaseous form it was first obtained by Priestley in 1744; and its true composition was shown by Davy in 1809, who proved it to be a compound of hydrogen and chlorine; hence it has been termed *hydrochloric acid*. Muriatic acid gas is procured by acting upon common salt (which is a chloride of sodium) by concentrated sulphuric acid. The water of the acid is decomposed, and its hydrogen combines with the chlorine of the salt to form muriatic acid; while the oxygen is transferred to the sodium, which is thus converted into soda, and this unites to the sulphuric acid to form sulphate of soda. 60 parts of common salt, and 49 parts of concentrated sulphuric acid, afford, by this mutual action, 87 parts of muriatic acid, and 72 of sulphate of soda. Muriatic acid gas may also be formed by passing an electric spark through a mixture of equal volumes of chlorine and hydrogen; or by exposing such mixture to the sun's rays, or inflaming them by a taper, they burn with explosion, and form a volume of muriatic acid equal to the united volumes of the gases. As the specific gravity of hydrogen is to that of chlorine as 1 to 36, the specific gravity of the resulting muriatic acid gas compared with hydrogen will be 18·5, and 100 cubic inches of it will weigh 39·3 grains. Muriatic acid gas is rendered liquid under a pressure of 40 atmospheres of the temperature of 50°; it extinguishes flame, and is intensely sour, powerfully reddening vegetable blues. Water absorbs it with much violence, taking up about 480 times its volume. This is the state in which muriatic acid is generally used. Its specific gravity is about 1·19, and it is commonly obtained by distilling a mixture of equal weights of salt, sulphuric acid, and water. When muriatic acid acts upon metallic oxides, it generally happens that a mutual decomposition of the oxide and acid ensues; the oxygen of the oxide unites to the hydrogen of the acid to form water, and the metal to the chlorine to form a metallic chloride. Thus it is that soda and muriatic acid form a chloride of sodium or common salt. The most effective test of the presence of muriatic acid is nitrate of silver, which forms an insoluble chloride of silver in all solutions containing muriatic acid or muriates.

The muriatic acid of commerce has usually a yellowish tinge, but when chemically pure it is colorless. It fumes strongly in the air, emitting a corrosive vapor of a peculiar smell. The straw color is due to the presence of chloride of iron, obtained from the vessel in which it was made. It may be freed from this by distillation.

The preparation of this acid upon a great scale is frequently effected in this country by acting upon sea-salt in hemispherical iron pots, or in cast-iron cylinders, with concentrated sulphuric acid; taking 6 parts of the salt to 5 of the acid. The mouth of the pot may be covered with a slab of silicious freestone, perforated with two holes of about two inches diameter each, into the one of which the acid is poured by a funnel in successive portions, and into the other, a bent glass, or stone-ware tube, is fixed, for conducting the disengaged muriatic gas into a series of large globes of bottle glass, one-third filled with water, and laid on a sloping sand-bed. A week is commonly employed for working off each pot; no heat being applied to it till the second day.

Liquid muriatic acid has a very sour corrosive taste, a pungent suffocating smell, and acts very powerfully upon a vast number of mineral, vegetable, and animal substances. It is much employed for making many metallic solutions; and in combination with nitric acid, it forms the aqua regia of the alchemists, so called from its property of dissolving gold.

MUSK is a peculiar aromatic substance, found in a sac between the navel and the parts of generation of a small male quadruped of the deer kind, called by Linnæus, Moschus moschiferus, which inhabits Tonquin and Thibet. The color of musk is blackish-brown; it is lumpy or granular, somewhat like dried blood, with which substance, indeed, it is often adulterated. The intensity of its smell is almost the only criterion of its genuineness. When thoroughly dried it becomes nearly scentless; but it recovers its odor when slightly moistened with water of ammonia. The Tonquin musk is most esteemed. It comes to us in small bags covered with a reddish-brown hair; the bag of the Thibet musk is covered with a silver-gray hair. All the analyses of musk hitherto made teach little or nothing concerning its active or essential constituent. It is used in medicines, and is an ingredient in a great many perfumes.

MUSK (*artificial*), is made of rectified oil of amber one part, nitric acid four parts, and digested. Black matter is deposited, to be well washed in water, and it smells similar to musk or ambergris, and may be used for them.

Musk Bolus. Mix in simple syrup 15 grains of musk with 5 grains of camphor. *Or*, with conserve of roses, half a scruple of musk and of sal ammoniac.

MUSKETS are bored, on the principle of turning, from a square length of iron, welded on a mandrel by heat into cylinders. In forming the spirals of rifle barrels, the borer is conducted by a matrix or female screw, which revolves in 2 feet, and the borer is fixed to a male screw. The spiral threads in a barrel are from 8 to 12. Cannon are cast as cylinders, and then bored.

The cylinders of steam engines are of solid cast-iron, bored in the usual manner, by forcing the cutters by a train of wheels towards the solid cylinder.

MUSLIN, a fine cotton fabric, used in ladies' dress. It is manufactured either white, dyed, or printed. It is also employed in artificial flower making.

MUST. The expressed juice of the grape before its conversion into wine by the process of fermentation.

MUSTARD. The seed of the *Sinapis alba* and *nigra*, ground into powder, and freed from the husks: it is the well-known condiment of the shops, or at least a part of it; for, in order to reduce the strength of the pure mustard, there is generally a considerable quantity of wheaten flour added. Brown mustard should be the flour of *Sinapis nigra* exclusively, which is much more pungent than the other. A dessert spoonful of coarsely powdered mustard-seed, taken in a glass of water, generally operates as an emetic; it is also aperient. A mustard poultice, or *sinapism*, is sometimes a useful stimulant.

Patent Mustard. In 15 gallons of water boil 10 lbs. of salt, and 12 lbs. of black ginger, strain, and to each gallon add 5 lbs. of flour of mustard.—For *Moutarde à l'estragon.* In a quart of Terragona sugar mix 2 oz. of salt, and 1 lb. of black mustard-seed, much dried, and finely powdered. This is the favorite French mustard.

MYRICINE, contained in beeswax, which contains from 20 to 30 per cent.; it remains behind when the wax is treated by alcohol.

MYRRH. This gum resin is imported from Turkey; it is in regular tears and lumps, of a reddish brown color, a fragrant odor, and a warm but bitter taste. It is probably the produce of a species of *Amyris*, said to be a native of Abyssinia and Arabia Felix. It is a good stimulating tonic medicine, and is given in doses of from five to twenty grains.

MYRTLE WAX is a concrete oil, or vegetable wax, the product of the class of plants *myrica*, known by the name of *candleberry myrtle*. It has too long been considered merely as an object of curiosity. The plant abounds in nearly all parts of North America, and varies in size from 4 to 18 feet, becoming taller as it extends into warmer regions. The bush or tree has somewhat the appearance of the common myrtle, and bears a berry of the size of the pepper-grain or coriander-seed. These grains are of a common ash-color, containing a small, round, hard kernel, which is covered with a shining wax, that may be obtained by boiling the grains in water. The wax is prepared for commerce along the Canadian lakes, and might, by proper attention, be rendered an important article of traffic. Tapers made of it, emit, when burning, the most delicious and balsamic odor, and the light is white and intense, equal to the best wax-candles.

NAILS are commonly made by hand by men or women, and also by machinery, invented by Church, the facility of which is so great, that the daily product is that of 12 workmen. A nail-smith, in Stirling, lately undertook to make 17,000 double flooring nails, 1200 to a thousand of 20 lbs., for two successive weeks. He finished his first week's task by 3 o'clock on Saturday afternoon; resumed his labor on Monday morning, and concluded his second week's task with more ease than the first. The quantity was as much as three ordinary men can perform, and allowing 25 strokes of the hammer (which was two lbs. weight) to each nail, there were no less than 1,033,656 strokes required. In addition to this he had to give from one to three blasts with his bellows for every nail, and had to move from the fire-place upwards of 42,836 times.

In Great Britain the majority of nails are hand-made: in this country they are almost altogether machine-made. In the nail-cutting machine they can be made for one-third the cost of wrought nails, to which they are superior for many purposes. The iron, after being rolled into plates and slit into rods, is flattened to the thickness of the future nail by a second rolling. The end of the plate is then presented to the nail-machine, by a workman, who turns the plate over once for every nail. The machine has a rapid reciprocating motion, and cuts off at every stroke a wedge-shaped piece of iron, constituting a nail without a head. This is immediately caught near its largest end, and compressed between gripes; at the same time, a strong force is applied to a die at the extremity, which spreads the iron sufficiently to form the head to the nail. Some nails are made of cast iron, but these are always brittle, unless afterwards they be converted into malleable iron by the requisite process.

Dr. Ure makes the following interesting quotation from a report of the Secretary of State for Massachusetts:

"To northern carpenters, it is well known that in almost all instances it is unnecessary to bore a hole before driving a cut nail; all that is requisite is, to place the cutting edge of the nail across the grain of the wood; it is also true, that cut nails will hold better in the wood. These qualities are, in some rough building works, worth twenty *per cent.* of the value of the article, which is equal to the whole expense of manufacturing. For sheathing and drawing, cut nails are full as good as wrought nails; only in one respect are the best wrought nails a little superior to cut nails, and that is where it is necessary they should be clinched. The manufacture of cut nails was born in our country, and has advanced, within its bosom, through all the various stages of infancy to manhood; and no doubt we shall soon be able, by receiving proper encouragement, to render them superior to wrought nails in every particular.

"The principal business of rolling and slitting-mills, is rolling nail plates; they also serve to make nail rods, hoops, tires, sheet iron, and sheet copper. In this State we have not less than twelve.

"These mills could roll and slit 7000 tons of iron a year; they now, it is presumed, roll and slit each year about 3500 tons, 2400 tons of which, probably, are cut up into nails and brads, of such a quality that they are good substitutes for hammered nails, and, in fact, have the preference with most people, for the following reasons; viz., on account of the sharp corner and true taper wth which cut nails are formed; they may be driven into harder wood without bending or breaking, or hazard of splitting the wood, by which the labor of boring is saved, the nail one way being the same breadth or thickness from head to point."

NANKEEN is a cotton cloth of a beautiful color, which derives its name from Nankin, in China, from which place it was first brought to Europe. The manufactured nankeen is now exported largely to China. Many suppose that true nankeen is artificially colored, but this is not so; its color is that of the natural cotton—a peculiar kind, some of which has been successfully cultivated in Georgia. The color of nankeen may be imitated in the most perfect manner, and in every case of linen drill of this color, may be set down as an artificial production.

To produce light nankeen shades, the cotton cloth should be first bleached white. This can be done by having some of the chloride of lime dissolved in cold water in a tub, using the clear hot, and handling the cloth in it till it is white, then handling it in a clean water, made sour to the taste, in a tub, by vitrol, and afterwards washing it well. It is then fit to be dyed: to do this, dissolve one pound of copperas in half a gallon of water, and dissolve two pounds of quick lime in 10 gallons of water; then let both solutions settle. Pour off five gallons of the clear lime water into a tub of clean cold water, sufficient to cover the cloth, and allow it to be handled by the selvedge freely. Then into another tub of cold water, about the same size as the lime water tub, put in one quarter of the clear dissolved copperas; one ounce of the nitrate of lead may be dissolved with the copperas; handle the cloth well for five or ten minutes in the lime, giving it three selvedges from end to end, and afterwards wring and shake it. It is now to be handled the same way in the copperas solution, then wrung and aired for ten minutes. It is then to be put through the lime and copperas in the same manner, adding enough of the strong lime and copperas to make three successive dips, airing well out of the copperas every time. It is then put through, last, a clean tub of lime water, which can be made by putting more clean water among the two lbs. of lime, letting it settle and using the clear. It is then well washed in water, then in a strong solution of soap, and afterwards well washed, then dried. This will also dye unbleached cotton cloth, which will be somewhat darker in the color. The quantities of lime and copperas given, will dye 30 yards of common cloth. Light and dark shades are produced by the quantity of lime and copperas used, and the number of dips given. The eye will judge the depth of color desired. Unbleached cotton cloth should be boiled for about one hour in lime water, then washed well before it is dyed.

Bleached goods sold in stores are difficult to color level—they always spot, owing to some chloride of lime not being thoroughly washed out of them. The only remedy for this is to steep the cloth all night in warm water, then boil it in lime water, and wash it well before it is dyed (and it would be all the better to be quickly handled in hot water, made sour with vitriol, and then well washed). This color washes well in strong soap suds, but it spots brown and black, if tea, coffee, or any solution containing galic acid, gets on it.

Madder Nankeen. This is the best nankeen color, as it will wash beautifully in soap, and not to be affected with weak acids.

Take the cotton cloth (unbleached) and boil it well in strong lime water for four or five hours, until all the natural oil which is contained in the fibres of the cotton is removed—this is essential to produce a good nankeen. If any of the oleaginous matter is left, the color will be too reddish, approaching to a salmon color. After the cotton is well boiled, it must be well washed, and then handled in a copper or tin kettle, kept near a scalding heat for one hour. In the kettle should be plenty of water, to allow free handling, and there should be four ounces of alum dissolved in it for every pound weight of the cotton. The goods after this are washed well, and then put into a kettle containing clean water, and four ounces of madder to every pound. It should be kept at a scalding heat for nearly one hour, when a beautiful nankeen color will be the result. The color is made deeper in the shade by using more stuff. It is washed out of the madder and is dried. If the cotton cloth was bleached it would make a still more beautiful color. By putting a little of yellow oak bark among the madder, it will make the color verge more upon the yellow shade.

Another way to dye nankeen is to boil annatto among pearlash (one ounce will color five pounds), and then mix it with hot water in a clean vessel, and handle the goods in it for fifteen or twenty minutes. This color is beautiful, but fugitive; it fades with the sun and can be boiled out with soap. It is of this colored stuff that so many yellow faded and spotted pantaloons are made.

In many cases, the ordinary mode of making nankeen varies from the foregoing processes, and consists in a series of operations, nearly as follows:

The clean cotton yarn is saturated in a solution of alum till it will soak in no more of that mordant. It is then *galled*, by dipping it in a strong bath of oak bark; then washed through a bath of cream of lime or weak soda lye, until the desired shade appears. The hanks are then rinsed, squeezed, and aired, and passed through a bath of chloride of tin, to brighten up the color.

NAPLES YELLOW is a fine yellow pigment, called *giallolino*, in Italy, where it has been long prepared by a secret process; for few of the recipes which have been published produce a good color. It is employed not only in oil-painting, but also for porcelain and enamel. It has a fresh, brilliant, rich hue, but is apt to be very unequal in different samples.

The following prescription has been confidently recommended. Twelve parts of metallic antimony are to be calcined in a reverberatory furnace, along with eight parts of red lead, and four parts of oxide of zinc. These mixed oxides, being well rubbed together, are to be fused; and the fused mass is to be triturated and elutriated into a fine powder. Chromate of lead has in a great measure superseded Naples yellow. A native paint is made from a species of lava.

NAPHTHA, the most fluid bitumen, is nearly colorless, but of a yellowish tinge, transparent, and emits a peculiar odor. It swims on water, its specific gravity being from 0·71 to 0·84. It burns with a bluish-white flame and thick smoke, and leaves no residue. It consists of carbon, 82·2, and hydrogen, 14·8; being the only fluid destitute of oxygen. It is found in Persia, in the peninsula of Apcheron, upon the western shore of the Caspian Sea, where it rises through a marly soil in the form of vapor, and, being made to flow through earthen tubes, is inflamed for the purpose of assisting in the preparation of food. It is collected by sinking pits several yards in depth, into which the naphtha flows. It is burned in lamps, by the Persians, instead of oil. Near the village of Amiano, in the state of Parma, there exists a spring, which yields this substance in sufficient quantity to illuminate the city of Genoa, for which purpose it is employed. In a coal mine near Manchester, England, there is a spring of Naphtha, welling up between the seams, and which yields 150 gallons a day.

On the surface of Seneca Lake, New-York, a large quantity of naphtha, or "rock oil," floats at particular periods of the year. This Seneca rock oil is derived from the bitumen escaping out of the shales which are very carbonaceous in the middle counties of western New-York. The shale beds dip south and a little west under the waters of the lake, and where the opening of the seams meets the water at the bottom of the lake the bitumen oozes out, and rises to the surface. There are many other localities on this continent, where native naphtha or bitumen is found. It is found abundantly in Kentucky. Any highly fossiliferous shale, which is dark colored from the large quantity of vegetable matter contained in it, and which also contains pyrites disseminated throughout, generally affords naphtha. Native naphtha boils at 201° F.

Artificial Naphtha is obtained by the distillation of the crude coal-tar, one of the residues of the manufacture of coal-gas. It has a specific gravity of ·857, and consists of carbon, 83·04; hydrogen, 12·31; oxygen, 4·35. Dr. Ure gives the boiling point as 316°; but this must have been a very impure naphtha. The chief and valuable agent in coal naphtha is Benzole (which see), which is obtained by distilling the coal-oil at a temperature not exceeding 185°. Coal naphtha is a valuable solvent for many solid hydro-carbons, as gutta percha and caoutchouc and when pure contains no oxygen. On this latter account it is the only substance suitable for preserving potassium and the other easily oxidized metals.

NAPHTHALIZED GAS. Mr. Lowe, of England, has patented a plan for producing illuminating gas, and increasing the power of coal-gas by passing it through naphtha. He charges the gas-meter with naphtha instead of water, and the gas, bubbling through it, becomes charged with the vapor of this hydro-carbon. This is the simplest way, but gas companies objecting, a separate vessel was attached, filled with pieces of sponges, charged with naphtha. This plan was found to act equally well. Gas produces 30 to 50 per cent. more light when naphthalized than when not, and on this account there is a saving of 20 per cent. in gas. It is also more favorable to the human countenance, and to the distinguishing of colors. An inferior gas can thus be made equal to a superior one; and hydrogen passed through naphtha is highly luminous. Carbonic oxide, and even carbonic acid, can be made to burn when naphthalized, and common air burns with a bright flame when fully charged with naphtha vapor.

NAPHTHALINE is a white crystalline solid, obtained during the rectification of coal-tar incrusting the pipes. It is also obtained in the purification of naphtha (Benzole) from coal-oil. It has a pungent aromatic smell, and a specific gravity, 1048. It is a hydro-carbon, containing carbon 94, and hydrogen 6, in 100 parts. It is one of the most highly carbonized products.

NARCOTINE, one of the constituents of opium, from which it may be obtained by the following process:—Evaporate opium; dry; add muriatic acid, or pyroligneous acid, at 4° or 5°; press out the liquor, add ammonia, wash the precipitate with boiling alcohol, at 86°, cool, and the narcotine will separate, and is purified by bone black.

NATRON, an impure carbonate of soda, originally brought from Egypt. Near Fozzan, in New Africa, it is found, and is called *Trona*. It is also found in Siberia, Tartary, Hindostan, and Mexico. In that republic there are several natron lakes, to the north of Zacatecas, as well as in other localities. In Columbia, 48 miles from Merida, it is dug up in large quantity from the bottom of the lakes.

NAVIGATION *of the United States*. The Annual Report on the Commerce and Navigation of the United States, by Senator Corwin, presents some very interesting information relative to the rapid increase of our internal commerce especially. In 1815 the tonnage of foreign shipping was 854,254 tons; of inland navigation tonnage, 513,818 tons. In 1850 the foreign tonnage had arisen to 1,585,711 tons, and the inland tonnage to 1,949,743. In 1815 the foreign tonnage exceeded the inland 60 per cent. Now, the inland exceeds the foreign 25 per cent. The "registered tonnage" has increased 700,000 tons; but the "enrolled and licensed" has increased 1,400,000 tons. The whole increase from 1820 to 1850 (a period of thirty years), is 175 per cent. Now the growth of population in that period is 130 per cent., proving the growth of commerce and navigation to be faster than that of the people. Among the most obvious causes of this fact is the introduction of steam navigation on the western rivers. The steam tonnage on all the western rivers exceeds 300,000 tons; but this had no existence in 1815, the period of comparison in the above table.

NEEDLE MANUFACTURE. This useful little article constitutes a large business, giving employment to many hundred operatives. The following is an outline of the various processes carried out:

The best steel, reduced by a wire-drawing machine to the suitable diameter, is the material of which needles are formed. It is brought in bundles to the needle factory, and carefully examined. For this purpose, the ends of a few wires in each bundle are cut off, ignited, and hardened by plunging them into cold water. They are now snapped between the fingers, in order to judge of their quality; the bundles belonging to the most brittle wires are set aside, to be employed in making a peculiar kind of needles.

After the quality of the steel wire has been properly ascertained, it is calibred by means of a gauge, to see if it be equally thick and round throughout, for which purpose merely some of the coils of the bundles of wires are tried. Those that are too thick are returned to the wire-drawer, or set apart for another size of needles.

The new made coil is cut in two points diametrically opposite, either by hand shears, of which one of the branches is fixed in a block by a bolt and a nut, or by means of the mechanical shears, the crank of which is moved by a hydraulic wheel, or steam power, and rises and falls alternately. The extremity of this crank enters into a mortise cut in the arm of a bent lever, and is made fast to it by a bolt. An iron rod, hinged at one of its extremities to the end of the arm, and at the other to the tail of the shears or chisel, forces it to open and shut alternately. The operative placed upon the floor, presents the coil to the action of the shears, which cut it into two bundles, composed each of 90 or 100 wires, upwards of 8 feet long. The chisel strikes 21 blows in the minute.

These bundles are afterwards cut with the same shears into the desired needle lengths, these being regulated by the diameter. For this purpose the wires are put into a semi-cylinder of the proper length, with their ends at the bottom of it, and are all cut across by this gauge. The wires, thus cut, are deposited into a box placed alongside of the workman.

Two successive incisions are required to cut 100 wires, the third is lost. Hence the shears, striking 21 blows a minute, cut in 10 hours 400,000 ends of steel wire, which produce 800,000 needles. The cut wires are bent, and have to be made straight; this is done by passing a flat iron plate or rule with great force once or twice over the cut bundles.

The wires are now taken to the pointing-tools, which usually consist of about 30 grindstones arranged in two rows, driven by a water-wheel. Each stone is about 18 inches in diameter, and 4 inches thick. As they revolve with great velocity, and are liable to fly in pieces, they are partially incased by iron plates, having a proper slit in them to admit of the application of the wires. The workman seated in front of the grindstone, seizes 50 or 60 wires between the thumb and forefinger of his right hand, and directs one end of the bundle to the stone. By means of a bit of stout leather called a thumb-piece, the workman presses the wires, and turns them about with his forefinger, giving them such a rotatory motion as to make their points conical. This operation, which is called *roughing down* is dry grinding; because, if water were made use of, the points of the needles would be rapidly rusted. It has been observed long ago, that the silicious and steel dust thrown off by the stones, was injurious to the eyes and lungs of the grinders; and many methods have been proposed for preventing its bad effects. The machine invented for this purpose by Mr. Prior, does away with much of this evil.

The flatted heads have become hardened by the blow of the hammer; when annealed by heating and slow cooling, they are handed to the *piercer*. This is commonly a child, who, laying the head upon a block of steel, and applying the point of a small punch to it, pierces the eye with a smart tap of a hammer, applied first upon the one side, and then exactly opposite upon the other.

Another child trims the eyes, which he does by laying the needle upon a lump of lead, and driving a proper punch through its eye; then laying it sidewise upon a flat piece of steel, with the punch sticking in it, he gives it a tap on each side with his hammer, and causes the eye to take the shape of the punch. The operation of piercing and trimming the eyes is performed by clever children with astonishing rapidity; who become so dexterous as to pierce with their punch a human hair, and thread it with another, for the amusement of visitors.

The next operative makes the groove at the eye, and rounds the head. He fixes the needle in pincers, so that the eye corresponds to their flat side; he then rests the head of the needle in an angular groove, cut in a piece of hard wood fixed in a vice, with the eye in an upright position. He now forms the groove with a single stroke of a small file, dexterously applied, first to the one side of the needle, and then to the other. He next rounds and smooths the head with a small flat file. Having finished, he opens the pincers, throws the needle upon the bench, and puts another in its place. A still more expeditious method of making the grooves and finishing the heads has been long used in most English factories. A small ram is so mounted as to be made to rise and fall by a pedal lever, so that the child works the tool with his foot; in the same way as the heads of pins are fixed. A small die of tempered steel bears the form of the one channel or groove, another similar die that of the other, both being in relief; these being worked by the lever pedal, finish the grooving of the eye at a single blow, by striking against each other, with the head of the needle between them.

The whole of the needles thus prepared are thrown pell-mell into a sort of drawer or box, in which they are, by a few dexterous jerks of the workman's hand, made to arrange themselves parallel to each other.

The needles are now ready for the tempering; for which purpose they are weighed out in quantities of about 30 pounds, which contain from 250,000 to 500,000 needles, and are carried in boxes to the *temperer*. He arranges these upon sheet-iron plates, about 10 inches long, and 5 inches broad, having borders only upon the two longer sides. These plates are heated in a proper furnace to bright redness for the larger needles, and to a less intense degree for the smaller; they are taken out, and inverted smartly over a cistern of water, so that all the needles may be immersed at the same moment, yet distinct from one another. The water being run off from the cistern, the needles are removed, and arranged by agitation in a box, as above described. Instead of heating the needles in a furnace, some manufacturers heat them by means of a bath of melted lead in a state of ignition.

After being suddenly plunged in the cold water, they are very hard and excessively brittle. The following mode of tempering them is practised at Neustadt. The needles are thrown into a sort of frying-pan along with a quantity of grease. The pan being placed on the fire, the fatty matter soon inflames, and is allowed to burn out; the needles are now found to be sufficiently well tempered. They must, however, be re-adjusted upon the steel anvil, because many of them get twisted in the hardening and tempering.

Polishing is the longest and not the least expensive process in the needle manufacture. This is done upon bundles containing 500,000 needles; and the same machine, under the guidance of one man, polishes from 20 to 80 bundles at a time, either by water or steam power. The needles are rolled up in canvas along with some quartzose sand interstratified between their layers, and the mixture is besmeared with rape-seed oil.

After polishing, the needles have to be *scoured*; this is done by putting them in a cask with sawdust. The cask turns on a winch handle, and the whirling motion rubs all the grease off the surface of the needles. The needles are then taken out and *winnowed*, or have the sawdust blown off them by a winnowing machine. They are then *arranged in order* by being dexterously shaken in a concave tray, and heaped up at one end, so that they can be removed in bundles by the hand.

Sorting of the needles. This operation is performed in a dry upper chamber, kept free from damp by proper stoves. Here all the points are first laid the same way; and the needles are then picked out from each other in the order of their polish. The sorting is effected with surprising facility. The workman places 2000 or 3000 needles in an iron ring, two inches in diametor, and sets all their heads in one plane; then, on looking carefully at their points, he easily recognizes the broken ones; and by means of a small hook fixed in a wooden handle, he lays hold of the broken needle and turns it out. These defective needles pass into the hands of another workman, who points them anew upon a grindstone, and they form articles of inferior value. The needles which have got bent in the polishing must now be straightened. The whole are finally arranged exactly according to their lengths by the tact of the finger and thumb of the sorter.

The needles are divided into quantities for packing in blue papers, by putting into a small balance the counterpoise of 100 needles, and so measuring them without the trouble of counting.

Drilled-eyed needles. Needles of the above named kind are made in this country, and by the original inventor, Mr. Wm. Essex, an Englishman. His factory is in a secluded nook of New Jersey, near Newark. The wire used is made in England expressly for the purpose — the manufacturers of this country not having yet accomplished the manufacturing of wire suited to this purpose. It is first cut into suitable lengths, according to the size of the needles to be made, when they ere straightened and pointed upon a stone which is required to be turned with great velocity; they are then stamped, or an impression made upon them where the eye is to be made; after which the eye is punched by means of a press invented for the purpose. The burr made by stamping the eye is filed smooth, after which the hardening and tempering is performed, and then they are again straightened so as to make their shape perfect. By means of machinery, they are scoured and brightened, and the closing processes are, the assorting them by placing the heads and points their respective ways; the eyes blued, or the temper at that point taken out, that they may not cut, and the drilling, countersinking and burnishing the eyes.

This peculiar branch of manufacturing, although not entirely new, is nevertheless of somewhat recent origin in this country.

NEEDLE, MAGNETICAL. A slender magnetized bar of steel, which, when suspended freely on a pivot or centre, arranges itself in the direction of the magnetic force of the earth.

NEEDLE ORE. (From the acicular form of its crystals.) A native sulphuret of bismuth, copper, and lead: it occurs in the gold mine of Schlangenberg, in Siberia.

NEEDLE STONE. A species of acicular zeolite found in Iceland.

NICOTINA. A poisonous alkaline base, extracted from the leaves and seed of the *Nicotiana tabacum*, or common tobacco. It derives its name from Nicot, a Frenchman, who, about 1560, first sent tobacco into France. To obtain it, the leaves are to be digested in acidulous water, evaporating the infusion to a certain point, adding lime to it, distilling, and treating the product which comes over with ether. It is colorless, has an acrimonious taste, a pungent smell, remains liquid at 20° F., mixes in all proportions with water, but is in a great measure separable from it by ether, which dissolves it abundantly. It combines with acids, and forms salts acrid and pungent like itself; the phosphate, oxalate, and tartrate being crystallizable. Nicotine causes the pupils to contract. A single drop of it is sufficient to kill a dog. It has acquired some notoriety as being the substance selected by Count Bocarmé to poison his brother-in-law with, and for which he suffered on the guillotine in 1851.

NITRATE OF AMMONIA is prepared by neutralizing nitric acid with carbonate of ammonia, and crystallizing the solution.

NITRATE OF LEAD is made by saturating somewhat dilute nitric acid with oxide of lead (litharge), evaporating the neutral solution till a pellicle appears, and then exposing it in a hot chamber till it be converted into crystals, which are sometimes transparent, but generally opaque white octahedrons. Their spec. grav. is 4·068; they have a cooling, sweetish, pungent taste. They dissolve in 7 parts of cold, and in much less boiling water; they fuse at a moderate elevation of temperature, emit oxygen gas, and pass into oxide of lead. Their constituents are 67·3 oxide, and 32·7 acid. Nitrate of lead is much employed in the chrome yellow style of CALICO-PRINTING; which see.

There are three other compounds of nitric acid and lead oxide; viz., the bi-basic, the tri-basic, and the sex-basic; which contain respectively 2, 3, and 6 atoms of base to 1 of acid.

NITRATE OF POTASH, *Nitre, Saltpetre.* This salt occurs native as an efflorescence upon limestones, sandstones, marls, chalk, and calctuff; it forms a saline crust in caverns, as also upon the surface of the ground in certain places, especially where animal matters have been decomposed. Such caverns exist in Germany near Homburg (Burkardush); in Apulia upon the Adriatic sea (Pulo di Mofetta), in France; in the East Indies; in Ceylon, where 22 nitriferous caverns are mentioned; in North America, at Crooked river, Tennessee, Kentucky, and upon the Missouri; in Brazil, Teneriffe, and Africa. Nitre occurs as an efflorescence upon the ground in Arragon, Hungary, Podolia, Sicily, Egypt, Persia, Bengal, China, Arabia, North America, and South America. Several plants contain saltpetre; particularly borage, dill, tobacco, sunflowers, stalks of maize, beet-root, bugloss, parietaria, &c. It has not hitherto been found in animal substances.

This salt consists of 54 nitric acid + 48 potassa; its equivalent, therefore, is 102. It is spontaneously generated in the soil, and crystallizes upon its surface in several parts of the world, especially in India, whence nearly the whole of the nitre used in Britain is derived. It has occasionally been produced artificially in *nitre beds*, formed of a mixture of calcareous soil with animal matter; in these, nitrate of lime is slowly formed, which is extracted by lixiviation, and carbonate of potash added to the solution, which, by double decomposition, gives rise to the formation of nitrate of potash and carbonate of lime: the latter is precipitated: the former remains in solution, and is obtained in crystals by evaporation. Nitre crystallizes in six-sided prisms, soluble in seven parts of cold water, and in less than its weight of boiling water. It has a cooling saline taste, and is anhydrous. At 616° it fuses, and at a red heat is decomposed. Its great use is in the manufacture of gunpowder, and in the production of nitric acid. It is also employed in the preservation of meat.

Dr. Ure, in his valuable Dictionary of Arts, discusses this interesting question —How is nitre annually reproduced upon the surface of limestones, and the ground, after it has been removed by washing? It has been said, in reply, that as secondary limestones contain remains of animal matters, the oxygen of the atmosphere, absorbed in virtue of the porous structure, will combine with their azote to form nitric acid; whence nitrate of lime will result. Where potash is present in the ground, a nitrate of that base will be next formed. The generation of nitre is in all cases limited to a very small distance from the surface of porous stones; no further, indeed, than where atmospherical air and moisture can penetrate; and none is ever produced upon the surface of compact stones, such as marble and quartz, or of argillaceous minerals. Dr. John Davy and M. Longchamp have advanced an opinion, that the presence of azotized matter is not necessary for the generation of nitric acid or nitrous salts, but that the oxygen and azote of the atmosphere, when condensed by capillarity, will combine in such proportions as to form nitric acid, through the agency of moisture and of neutralizing bases, such as lime, magnesia, potash, or soda. They conceive that as spongy platina serves to combine oxygen and hydrogen into water, or the vapor of alcohol and oxygen into acetic acid, and as the peroxyde, as well as the hydrate of iron and argillaceous minerals, serve to generate ammonia from the oxygen of the air and the hydrogen of water; in like manner, porous limestones, through the agency of water, operate upon the constituents of the atmosphere to produce nitric acid, without the presence of animal matter. This opinion may certainly be maintained; for in India, Spain, and several other countries, at a distance from all habitations, immense quantities of saltpetre are reproduced in soils which have been washed the year before. But, on the other hand, it is known that the production of this salt may be greatly facilitated and increased by the admixture of animal offals with calcareous earths.

It is now known, that ammonia in the nascent state, or just in the moment of being generated by decomposition of animal matters, is converted into nitric acid, if a stronger base, such as lime or potash, be present: the oxygen of the air is brought into play, and, uniting with the ammonia just formed, alters that substance into nitric acid and water; 8 equivalents of oxygen uniting with 1 equivalent of ammonia, to form 1 equivalent of nitric acid and 3 equivalents of water. The acid thus produced then seizes on the potash, and becomes neutralized. This explains why animal matter, and stirring the compost, hastens nitrification.

Nitre is applied to many purposes:—1, to the manufacture of gunpowder; 2, to that of sulphuric acid; 3, to that of nitric acid, though nitrate of soda or cubic nitre has lately superseded this use of it to a considerable extent; 4, to that of flint-glass; 5, it is used in medicine; 6, for many chemical and pharmaceutical preparations; 7, for procuring, by deflagration with charcoal or cream of tartar, pure carbonate of potash, as also black and white fluxes; 8, for mixing with salt in curing butcher meat; 9, in some countries for sprinkling in solution upon grain, to preserve it from insects; 10, for making fireworks.

Nitre has sometimes been mistaken for Glauber's salt; and, when taken in the quantity of half an ounce or an ounce, it acts as a powerful poison. In such cases the stomach should be evacuated as rapidly as possible, and the symptoms of spasm relieved by opiates. In doses of 5 to 15 grains it is diuretic and diaphoretic.

NEPHELINE. A mineral from Somma, near Vesuvius, and Capo di Bovo, near Rome; in nitric acid its transparent fragments become *cloudy*. It is a double selicate of alumina and soda. It is also known by the name of *sommite*.

NEPHRITE. A hard, tough mineral, composed chiefly of silica, with lime, soda, and potash. It is difficult to break, cut, or polish; it is slightly translucent, and usually of a greenish color. It is occasionally manufactured into sword and knife handles, and has even been cut into the form of a chain, which, from its extreme toughness, is not easily broken. Little plates of it were formerly suspended from the neck for the cure of *nephritic* complaints, whence its name. The Chinese are celebrated for articles composed of it. Its essential components are silica, alumina, and magnesia.

NEROLI. Essential oil of orange flowers. It is procured by distillation with water, in the same way as the other essential oils.

NESTS, ESCULENT. A species of nests built by swallows peculiar to the Indian islands, and very much esteemed in China and other parts of the world. These nests resemble in form those of other swallows; they are formed of a viscid substance, and in external appearance, as well as consistence, are not unlike fibrate ill-concocted isinglass. Esculent nests are principally found in Java, in caverns usually situated on the sea-coast. Nothing satisfactory is known as to the substance of which these nests are composed.

NET, or NEAT. In commerce, something pure and unadulterated with any foreign mixture. Thus, wines are said to be *net* when not falsified; and coffee, rice, &c., to be so, when the filth and ordures are separated from them. The word *net* is also used for what remains after the tare has been taken out of any merchandise—*i. e.*, when it is weighed clear of all package. *Net Produce* (Ital. netto proceduto) is used in mercantile language to express what any commodity has yielded, after all tare and charges have been deducted.

NET is a textile fabric of knotted meshes for catching fish, and other purposes. Each mesh should be so secured as to be incapable of enlargement or diminution. The French Government offered, in 1802, a prize of 10,000 francs to the person who should invent a machine for making nets upon automatic principles, and adjudged it to M. Buron, who presented his mechanical invention to the *Conservatoire des Arts et Métiers*. It does not appear, however, that this machine has accomplished the object in view; for no establishment was ever mounted to carry it into execution. Nets are usually made by the fishermen and their families during periods of leisure.

NEUTRALIZATION. In chemistry, the combination of an acid and alkali in such proportions that the peculiar properties of each are rendered inert.

NEUTRAL SALTS. This term is applied to all salts which contain an acid saturated with an alkali, an earth, or a metal. Bergmann confined it to salts containing alkali; and he called the earthy and metallic salts, middle salts. It was most usual to call the alkaline salts with an acid neutral, and to distinguish the others by the respective appellations, earthy and metallic; but the term neutral is now applied to those salts which contain 1 equivalent of acid and 1 equivalent of base.

NICARAGUA WOOD is obtained from the *cæsalpinia echinata*, a tree growing in Mexico. With solution of tin as a mordant, it gives a bright but fugitive red. It is inferior in dyeing power to Brazil wood.

NICKEL is a silver-like metal, sp. gr. 8·9. It is magnetic, and is greedy of oxygen, forming gray protoxide and black peroxide. Heat will not oxidate it because it drives off oxygen as fast as it fixes; but the oxides are formed by solution in nitric acid, precipitating by potash, and then heating to redness. It is usually associated with cobalt: it is always present in meteoric stones: in the Harz Mountains it is associated with copper, as *kupfernickel ore*; with arsenic and iron, as *arsenic-nickel*. It also exists as an oxide, a sulphuret, and an arseniate, in gneiss, mica slate, and sienite.

The chief of these ores, and that from which most of the nickel of Conemera is obtained, is the copper-colored ore above described as *kupfernickel*—nickel being a term of detraction used by the German miners, who expected from the color of the ore to find that it contained copper. The salifiable oxide of nickel consists of 30 nickel + 8 oxygen. Its salts are mostly of a grass-green color, and the ammoniacal solution of its oxide is deep blue, like that of copper. Ferrocyanate of potassa precipitates it of a white or very pale green color.

Since the manufacture of German silver, or *argentine*, became an object of commercial importance, the extraction of nickel has been undertaken upon a considerable scale. The cobalt ores are its most fruitful sources, and they are now treated by the method of Wöhler to effect the separation of the two metals. The arsenic is expelled by roasting the powdered *speiss* first by itself, next with the addition of charcoal powder, till the garlic smell be no longer perceived. The residuum is to be mixed with three parts of sulphur and one of potash, melted in a crucible with a gentle heat, and the product being edulcorated with water, leaves a powder of metallic lustre, which is a sulphuret of nickel free from arsenic;

while the arsenic associated with the sulphur, and combined with the resulting sulphuret of potassium, remains dissolved. Should any arsenic still be found in the sulphuret, as may happen if the first roasting heat was too great, the above process must be repeated. The sulphuret must be finally washed, dissolved in concentrated sulphuric acid, with the addition of a little nitric; the metal must be precipitated by a carbonated alkali, and the carbonate reduced with charcoal.

In operating upon kupfernickel, or speiss, in which nickel predominates, after the arsenic, iron, and copper have been separated, ammonia is to be digested upon the mixed oxides of cobalt and nickel, which will dissolve them into a blue liquor. This being diluted with distilled water deprived of its air by boiling, is to be decomposed by caustic potash till the blue color disappears, when the whole is to be put into a bottle tightly stoppered, and set aside to settle. The green precipitate of oxide of nickel, which slowly forms, being freed by decantation from the supernatant red solution of oxide of cobalt, is to be edulcorated and reduced to the metallic state in a crucible containing crown glass. Pure nickel, in the form of a metallic powder, is readily obtained by exposing its oxalate to moderate ignition.

Since the application of Liebig's cyanide of potassium to the separation of metals in a mixed solution, the foregoing mode is generally given up for the use of the cyanide. A solution of cyanide of potassium is added to the mixed oxide, and heat applied. The cyanide must be quite free from cyanate. The solution is boiled to drive off excess of acid. Peroxide of mercury is then added to the solution, when the nickel is precipitated, partly as oxide, partly as pure metal: it is then collected, dried, and calcined, at a red heat, leaves the oxide perfectly free from cobalt.

NITRATE OF SILVER is prepared by saturating pure nitric acid of specific grav. 1·25 with pure silver, evaporating the solution, and crystallizing the nitrate. When the drained crystals are fused in a platina capsule, and cast into slender cylinders in silver moulds, they constitute the lunar caustic of the surgeon. This should be white, and unchangeable by light. It is deliquescent in moist air. The crystals are colorless, transparent 4 and 6 sided tables; they possess a bitter, acrid, and most disagreeable metallic taste; they dissolve in their own weight of cold, and in much less of hot water; are soluble in four parts of boiling alcohol, but not in nitric acid; they deflagrate on redhot coals, like all the nitrates; and detonate with phosphorus when the two are struck together upon an anvil. They consist of 68·2 of oxide, and 81·8 of acid. Nitrate of silver, when swallowed, is a very energetic poison; but it may be readily counteracted, by the administration of a dose of sea-salt, which converts the corrosive nitrate into the inert chloride of silver. Animal matter, immersed in a weak solution of neutral nitrate of silver, will keep unchanged for any length of time; and so will polished iron or steel. Nitrate of silver is such a delicate reagent of hydrochloric or muriatic acid, as to show by a sensible cloud, the presence of one 113 millionth part of it, or one 7 millionth part of sea-salt in distilled water. It is much used under the name of indelible ink, for writing upon linen with a pen; for which purpose one drachm of the fused salt should be dissolved in three quarters of an ounce of water, adding to the solution as much water of ammonia as will redissolve the precipitated oxide, with sap-green to color it, and gum-water to make the volume amount to one ounce. Traces written with this liquid should be first heated before a fire to expel the excess of ammonia, and then exposed to the sun-beam to blacken. Another mode of using nitrate of silver as an indelible ink, is to imbue the linen first with solution of carbonate of soda, to dry the spot, and write upon it with a solution of nitrate of silver, thickened with gum, and tinted with sap-green.

NITRATE OF SODA, *Cubical Nitre*, occurs under the nitre upon the lands in Spain, India, Chili, and remarkably in Peru, in the districts of Atacama and Taracapa, where it forms a bed several feet thick. It appears in several places upon the surface, and extends over a space of more than 40 leagues, approaching near to the frontiers of Chili. It is sometimes efflorescent, sometimes crystallized, but oftener confusedly mixed with clay and sand. This immensely valuable deposit is only three days' journey from the port of Conception in Chili, and from Iquiqui, another harbor situated in the southern part of Peru.

Nitrate of soda may be artificially prepared by neutralizing nitric acid with soda, and crystallizing the solution. It crystallizes in rhomboids, has a cooling, pungent, bitterish taste, less disagreeable than nitre; it becomes moist in the air; dissolves in 8 parts of water at 60° F., in less than 1 part of boiling water; deflagrates more slowly than nitre, and with an orange yellow-flame. It consists, in its dry state, of 36·6 soda 63·4 nitric acid; but its crystals contain one prime equivalent of water; hence they are composed of, acid 56·84, base 33·68, water 9·47.

It is susceptible of the same applications as nitre, with the exception of making gunpowder; for which it is not adapted, on account of its deliquescent property.

Its chief uses are in the manufacture of nitric acid, and as a manure. It has a remarkable effect in increasing the growth of leaf in plants, and is only second to the ammoniacal manures in power.

NITRATE OF STRONTIA. This salt is usually prepared from the sulphuret of strontium, obtained by decomposing sulphate of strontia with charcoal, by strong ignition of the mixed powders in a crucible. This sulphuret being treated with water, and the solution being filtered, is to be neutralized with nitric acid, as indicated by the test of turmeric paper; care being taken to avoid breathing the noxious sulphureted hydrogen gas, which is copiously disengaged. The solution, which requires to be properly evaporated and set aside, affords colorless crystals, of a slender octohedral form. It effloresces when heated, and gives a fine powder, which, when mixed with charcoal and chlorate of potash, affords the brilliant red light of the theatres.

NITRIC ACID exists, in combination with the bases, potash, soda, lime, magnesia, in both the mineral and vegetable kingdoms. This acid is never found insulated. It was distilled from saltpetre so long ago as the 13th century, by igniting that salt, mixed with copperas or clay, in a retort. Nitric acid is generated when a mixture of oxygen and nitrogen gases, confined over water or an alkaline solution, has a series of electrical explosions passed through it.

This acid is a compound of 1 atom or equivalent of nitrogen = 14, and 5 of oxygen (8 × 5) = 40; hence its equivalent in the dry or anhydrous state, as it exists, for instance, in nitre, is 14 + 40 = 54. As it usually occurs in the liquid state, it is a compound of 1 equivalent of dry acid, 54, and 2 of water (9 × 2), 18; hence the equivalent of the liquid acid is 72. It is commonly known in commerce under the name of *aqua fortis*, and is prepared by distilling a mixture of sulphuric acid and nitre. It is commonly yellow, or even deep orange colored; but it may be deprived of nitric oxide, which occasions this color, by heat, and is then colorless. It is intensely corrosive and sour, fumes when exposed to air, and has a specific gravity of 1·50 when in its utmost state of concentration. It boils at 248°, and freezes at —50°. It is a most powerfully oxidizing agent, and is decomposed with more or less rapidity by almost all the metals.

The salts which it forms are called *nitrates*; they are all soluble in water; they are decomposed by heat, and, when mixed and gently heated with sulphuric acid, they evolve nitric or nitrous acid.

On the small scale nitric acid may be made by heating together nitrate of potash and diluted oil of vitrol in atomic proportions: a receiver or flask should be attached to the tube of the retort and kept cool by immersion in water. Cold should also be applied to the neck of the retort. When the mixture begins to boil, red fumes come off, which cease after awhile, and reappear at the close of the process. To obtain a pure acid it is necessary to change the receivers and reject the first and last portions of the distillation, which contain the nitrous acid fumes, chlorine, and perhaps, sulphuric acid. That which distills over, when pure, is the concentrated acid having a density of 1·492.

On the large scale, iron retorts are used similar to them, in which hydrochloric acid is obtained.

Nitrate of soda is now generally used in place of nitre, as affording more acid and being a cheaper salt. The acid obtained thus contains a nitrate of iron, and requires redistillation before it can be gotten rid of. Nitric acid, of a density of 1·47, may be had, colorless; but when farther concentrated, it is partially decomposed; whereby some nitrous acid is produced, which gives it a straw-yellow tinge. At this strength it exhales white or orange fumes, which have a peculiar, though not very disagreeable smell; and even when largely diluted with water, it tastes extremely sour. The greatest density at which it can be obtained is 1·51 or perhaps 1·52, at 60° F., in which state, or even when much weaker, it powerfully corrodes all animal, vegetable, and most metallic bodies. When slightly diluted it is applied, with many precautions, to silk and woollen stuffs, to stain them of a bright yellow hue.

In the dry state, as it exists in nitre, this acid consists of 26·15 parts by weight of azote, and 73·85 of oxygen; or of 2 volumes of the first gas, and 5 volumes of the second.

When of specific gravity 1·5, it boils at about 210° Fahr.; of 1·45, it boils at about 240°; of 1·42, it boils at 253°; and of 1·40, at 246° F. If an acid stronger than 1·420 be distilled in a retort, it gradually becomes weaker; and if weaker than 1·42, it gradually becomes stronger, till it assumes that standard density. Acid of specific gravity 1.485 has no more action upon some metals, as tin, than water has, though when either stronger or weaker it oxidizes it rapidly, and evolves fumes of nitrous gas with explosive violence. Acid of 1·420 consists of 1 atom of dry acid, and 4 of water; acid of 1·485, of 1 atom of dry acid, and 2 of water; the latter compound possesses a stable equilibrium as to chemical agency; the former as to calorific. Acid of specific gravity 1·334, consisting of 7 atoms of water, and 1 of dry acid, resists the decomposing agency of light. Nitric acid acts with great energy upon most combustible substances, simple or compound, giving up oxygen to them, and resolving itself into nitrous gas, or even azote. Such is the result of its action upon hydrogen, phosphorus, sulphur, charcoal, sugar, gum, starch, silver, mercury, copper, iron, tin, and most other metals.

NITRIC OXIDE, or NITROUS GAS. This gas was discovered by Hales, and more accurately studied by Priestley. It is obtained during the action of nitric acid diluted with about two parts of water upon metallic copper; it is copiously evolved, and may be collected over water. One hundred cubical inches of this gas weigh between 32 and 33 grains; its density, therefore, compared with air, is 1037. It is at once easily recognized by forming orange-colored fumes whenever it escapes into the air or comes into contact with oxygen, so that this gas and oxygen are excellent tests of each other's presence. It consists of equal volumes of nitrogen and oxygen, or of 1 equivalent of nitrogen and 2 of oxygen; hence it is termed a binoxide or deutoxide of nitrogen. The respective weight of its components, therefore, are 14 nitrogen + 16 oxygen, and the equivalent of the gas is 30.

NITRITES. Salts of the nitrous acid; thus *nitrite* of potassa is a compound of 1 atom of nitrous acid and 1 atom of potassa, &c.

NITROGEN. A simple gaseous body which forms a constituent part of nitric acid, and which, being unrespirable, has also been termed *azote*. It was identified as a peculiar gas by Dr. Rutherford in 1774, and shown to be one of the components of atmospheric air by Lavoisier in 1774. It is generally obtained by burning a piece of phosphorus in a jar full of air inverted over water. The phosphorus during its combustion combines with the oxygen of the air to form phosphoric acid, which is dissolved by the water, and the remaining element of the air, namely, the nitrogen, remains. Nitrogen is a colorless, inodorous, and tasteless gas, not absorbed by water, and having no action on vegetable colors. It extinguishes all burning bodies, and is itself uninflammable. It is a little lighter than atmospheric air, 100 cubic inches weighing 30·16 grains. Its equivalent is 14, and it combines with oxygen in 5 proportions, giving rise to the following compounds:

	By volume.		By weight.		Equiv.	Symbols.
	N.	O.	N.	O.		
1. Nitrous oxide	100 +	50 =	14 +	8 =	22 =	$n + o$.
2. Nitrous oxide	100 +	100 =	14 +	16 =	30 =	$n + 2o$
3. Hyponitrous acid	100 +	150 =	14 +	24 =	38 =	$n + 3o$
4. Nitrous acid	100 +	200 =	14 +	32 =	46 =	$n + 4o$.
5. Nitric acid	100 +	250 =	14 +	40 =	54 =	$n + 5o$

NITRO-MURIATIC ACID, *Aqua regia*, is the compound menstruum invented by the alchemists for dissolving gold. If strong nitric acid, orange-colored by saturation with nitrous gas (deutoxide of azote), be mixed with the strongest liquid muriatic acid, no other effect is produced than might be expected from the action of nitrous acid of the same strength upon an equal quantity of water; nor has the mixed acid so formed any power of acting upon gold or platina. But if colorless aquafortis and ordinary muriatic acid be mixed together, the mixture immediately becomes yellow, and acquires the power of dissolving these two noble metals. When gently heated, pure chlorine gas rises from it, and its color becomes deeper; when further heated, chlorine still rises, but now mixed with nitrous acid gas. If the process has been very long continued, till the color becomes very dark, no more chlorine can be procured, and the liquor has lost the power of dissolving gold. It then consists of nitrous and muriatic acids. It appears, therefore, that aqua regia owes its peculiar properties to the mutual decomposition of the nitric and muriatic acids; and that water, chlorine, and nitrous acid gas are the results of that reaction. Aqua regia does not, strictly speaking, oxidize gold and platinum; it causes merely their combination with chlorine. It may be composed of very different proportions of the two acids; the nitric being commonly of specific gravity 1·34; the muriatic, of specific gravity 1·18 or 1·19. Sometimes 8 parts, and at others 6 parts of the muriatic acid are mixed with 1 of nitric. It may also be made by adding nitre to muriatic acid.

NITRO-NAPTHALASE. A compound resulting from the action of nitric acid on napthalin: a modification of it has been termed *nitro-napthalese.*

NITRO-SACCHARIC ACID. By the action of sulphuric acid on gelatine a peculiar saccharine matter is formed, which combines with nitric acid, and forms a crystallized acid designated as above.

NITRO-SULPHURIC ACID. An acid resulting from the mixture of one part of nitre with eight or ten parts of sulphuric acid. It was originally proposed by Mr. Keir as a useful agent for separating the silver from the copper of old plated goods. At the temperature of about 200° it dissolves silver, while it scarcely acts upon copper or lead, unless diluted, or at higher temperatures.

NITROUS ACID. When two volumes of nitric oxide and one of oxygen are mingled in an exhausted glass globe they form a dense orange-colored vapor, which may be liquefied by cold, and which is *nitrous acid.* Its elements are so condensed that 1 volume of nitrogen and 2 of oxygen form 1 volume of nitrous acid vapor, the specific gravity of which is 3·17. The presence of this vapor renders nitric acid red and fuming, in which state it is commonly termed *nitrous* acid.

NITROUS OXIDE. Protoxide of nitrogen; a gas obtained by heating nitrate of ammonia, which salt is thus resolved into nitrous oxide gas and water. When nitrous oxide is respired, it produces effects somewhat similar to those of intoxication; hence it has been called *laughing gas.*

NITROUS ETHER, or *Sweet Spirit of Nitre*, is made by putting three pints of alcohol into a bottle placed in cold water, and adding by degrees one pint of nitrous acid. Let it stand for seven days, and then distil it at a moderate heat into a cooled receiver. It is diuretic and antifebrile, taken in half a tea-spoonful or tea-spoonful in a glass of water, or barley-water.

NOOTH'S APPARATUS. This is used to impregnate water with gases. Three glass vessels are connected over one another. The lower contains the gas-making materials, marble and muriatic acid, with an orifice closed to admit more. The second is filled with water, and a valve and the gas, rising into it, soon fill both vessels with impregnated water. The gas passes through the second vessel, where it is washed, and collects in the upper one. Woolfe, Pepys, Knight, and Hamilton have improved it.

NOPAL. The *Cactus Opuntia.* This is the tree on which the Cochineal insect lives. It grows in Mexico.

NOTES, in printing are—shoulder notes: these are at the top of the page in the outer margin, and contain the book, chapter or date, or both of them; side notes or marginal notes, which give an abstract of the text, as in acts of parliament; or parallel passages, and different readings, as in the Bible; and bottom notes, or foot notes, which are placed at the bottom of the page, and generally contain commentaries and annotations.

NOTE. *Bank note, manufacture of.* A block of thick plate steel is softened on the upper side; the device is engraved on this softened surface; the block is hardened by a careful process after the engraving; the device is transferred from the hardened block to the convex surface of a small soft steel roller, by intense pressure; the roller is hardened, and the device is transferred from it to any number of softened steel plates; these plates are hardened after the transfer, and are then in a state to be printed from. By this beautiful train of operations, one originally engraved block is made to suffice for an almost endless number of engravings. The mode in which the writing, the emblems, and the ornaments are combined in a bank-note, is so planned as to render forgery difficult. The numbering is a remarkable process, as now performed. Four wheels, each divided by ten notches, leaving a face between each pair, engraved with consecutive numbers from 1 to 0, are placed upon a shaft: a portion of their breadth being turned down about one half of their depth, having a boss or collar between every two. Upon these bosses, and filling up the spaces, rest latches; and over each wheel is a pall, the width of the first being equal to that of the unit wheel, and the breadth of the others equalling that of the wheel and latch. The palls are driven by a crank; by each revolution of which the first wheel is moved through a space equal to one-tenth of its entire circumference, bringing regularly forward the numbers from 1 to 0. When the figure 0 is reached, the latch of the second wheel is depressed, and the wheel moves forward one division, making the tens. The same process is repeated with regard to the other wheels, and thus any amount of numbers can be registered, by simply increasing the number of wheels in proportion. Machines of this kind are extensively adopted in the Bank of England; with, of course, an inking apparatus to apply to the types. A patent was taken out in 1844 for a mode of printing bank-notes intended to obviate the liability to forgery. The surface is covered with two designs, one geometrically regular, and the other very irregular; the two designs are engraved on different plates, and are printed with different inks, the one with visible and the other with invisible ink. Both of the inks are delible, or removable by chemical means; and the usual engraving of a bank note is printed on paper so prepared. The rationale of the suggestion is this—that whatever means a forger might take to alter, by chemical agency, the letters or figures, or to transfer them by lithographic or anastic processes, the state of the paper would betray him; for he would remove some parts of the design in the one case, and fail to transfer in the other.

NOVACULITE. The stone of which hones are made for sharpening razors. It is of a slaty structure, and owes its quality of giving an edge to the metal to the fine silicious particles which it contains.

NUT OF A SCREW. In architecture, a piece of wood, iron, or other metal, pierced cylindrically, wherein is cut a spiral groove, adapted to an external cylindrical spiral cut on a bolt. Its use is to screw two bodies together, a head being placed on one end of the bolt to counteract the action of the nut. Two bodies are thus held together by compression, the bolt between the head and the nut being a tie.

NUTS. The fruit of different species of *Coryli* or hazels. The kernels have a mild farinaceous oily taste, agreeable to most palates; a kind of chocolate has been prepared from them, and they have sometimes been made into bread. The expressed oil of hazel nuts is little inferior to that of almonds. Besides those raised at home, nuts are imported from different parts of France, Portugal, and Spain, but chiefly from the latter. The Spanish nuts in highest estimation, though sold by the name of Barcelona nuts, are not shipped from thence, but from Tarragona, whence the average annual export is estimated at from 25,000 to 80,000 bags, four to the ton.

NUTTALITE. A mineral associated with calcspar, from Bolton, in Massachusetts: it occurs in prismatic crystals, and appears, from Dr. Thomson's analysis, to be an alumino-silicate of lime, potash, and iron.

NUTMEG-TREE. A native of the Molucca, or Spice Islands, principally confined to that group denominated the Islands of Banda, lying in lat. 4° 30′ south. It bears both blossom and fruit, at all seasons of the year, and assists with other aromatic trees and shrubs, to form that atmosphere of fragrance, in the upper regions of the air, in which the natives believe the birds of paradise perpetually float.

While the Dutch remained possessors of the Spice Islands, the quantity of nutmegs and mace exported from their nutmeg-grounds, circumscribed as they were, was enormous; 250,000 lbs. annually used to be vended in Europe, and nearly half that amount in the East Indies. Of *mace*, the average has been 90,000 lbs sold in Europe, and 10,000 lbs. in the East Indies.

When the Islands were taken by the British, in 1796, the importations of the East India Company into England alone, in the two years following the capture, were, of nutmegs, 129,732 lbs., and of mace 286,000 lbs. When the crops of spice were superabundant, and the price likely to be reduced, the Dutch destroyed immense quantities of the fruit. A Hollander informed Sir Wm. Temple, that, at one time, he saw three piles of nutmegs burnt, each of which was larger than a church could hold.

In the Moluccas, the gathering of the fruit takes place at three periods, in July or August, when the nutmegs are most abundant, but the mace thinner than in smaller fruits, gathered in November; the third harvest is in March or April, when the nuts, as well as the mace, are in the greatest perfection. The outer pulpy coat is removed, and, afterwards, the mace, with a knife. The nuts are placed over a slow fire, when the shell becomes very brittle, and the seeds, or nutmegs, drop out; these are then soaked in sea-water, and impregnated with lime, a process which answers the double purpose of securing the seeds from the attack of insects, and of destroying their vegetating property. It further prevents the volatilization of the aroma. The mace is simply dried in the sun, and then sprinkled with salt-water, after which it is fit for exportation.

The color, when fresh, is a brilliant scarlet. When dry, it becomes much more horny, of a yellow-brown color, and very brittle. The shell very hard, rugged dark-brown, glossy, about half a line thick, pale and smooth within. This immediately envelopes the seed, or nutmeg, which is of an oval elliptical form, pale brown, quite smooth, when first deprived of its shell, but soon becomes shrivelled, so as to have irregular, vertical lines, or furrows on its surface. Its outside very thin; its inner substance or albumen is firm, but fleshy, whitish, but so traversed with red-brown veins, which abound in oil, as to appear beautifully marbled. Near the base of the albumen, and imbedded in a cavity in its substance, is situated the embryo, which is large, fleshy, yellowish-white, rounded below, where is the radicle; its cotyledons, of two large, somewhat foliaceous, plicate lobes, in the centre of which is seen the plumule.

NUTRIA. The commercial name for the skins of *Myopotamus Bonariensis*, the *Coypou* of Molina, and the *Quoiya* of D'Azara. In France the skins were, and perhaps still are, sold under the name of *raconda;* but in England they are imported as *nutria* skins—deriving their appellation, most probably, from some supposed similarity of the animal which produces them, in appearance and habits, to the otter, the Spanish name for which is nutria. Indeed, Molina speaks of the *coypou* as a species of water-rat of the size and color of the otter.

In England, nutria fur is largely used in the hat manufacture, and has become, within the last 15 or 20 years, an article of very considerable commercial importance. The imports fluctuate considerably. In 1823, they amounted to 1,570,103 skins; but they have not, in any other year, been much more than half that number. In 1826, they were only 60,871. In 1837 and 1838, the imports were, at an average, 858,280 skins a year. Those entered for home consumption pay a duty of 1½d. a skin. They are principally brought from the Rio de la Plata. Nutria skins are very extensively used on the continent. Geoffrey mentions that, in certain years, a single French furrier (M. Bechem) has received from 15,000 to 20,000 skins.

Like the beaver, the coypou is furnished with two kinds of fur—viz., the long ruddy hair, which gives the tone of color, and the brownish ash-colored fur at its base, which, like the down of the beaver, is of much importance in hat making, and the cause of the animal's commercial value.

The habits of the coypou are much like those of most of the other aquatic Rodent animals. Its principal food, in a state of nature, is vegetable. It affects the neighborhood of water, swims perfectly well, and burrows in the ground. The female brings forth from five to seven at a time, and the young always accompany her.

The coypou is easily domesticated, and its manners in captivity are very mild.

OAK. The general name of a well known hard-wooded forest tree, much cultivated for the purposes of timber, particulary in ship-building, and in other cases where much exposure to the weather is required. There are several varieties of this valuable tree; but the common English oak (*Quercus robur*) claims precedence of every other of European growth. The knotty oak of England, the "unwedgeable and gnarled oak," as Shakspeare called it, when cut down at a proper age (from 50 to 70 years), is the best timber known. Some timber is harder, some more difficult to rend, and some less capable of being broken across; but none contains all the three qualities in so great and equal proportions; and thus, for at once supporting a weight, resisting a strain, and not splintering by a cannon-shot, the timber of the oak is superior to every other.

A fine oak is one of the most picturesque of trees: it conveys to the mind associations of strength and duration which are very impressive. The oak stands up against the blast, and does not take, like other trees, a twisted form from the action of the winds. Except the cedar of Lebanon, no tree is so remarkable for the stoutness of its limbs; they do not exactly spring from the trunk, but divide from it; and thus it is sometimes difficult to know which is stem and which is branch. The twisted branches of the oak, too, add greatly to its beauty; and the horizontal direction of its boughs, spreading over a large surface, completes the idea of its sovereignty over all the trees of the forest.

The oak is raised from acorns, sown either where the oak is to stand, or in a nursery whence the young trees are transplanted.

The color of oak wood is a fine brown,

and is familiar to every one: it is of different shades; that inclined to red is the most inferior kind of wood. The larger transverse septa are in general very distinct, producing beautiful flowers when cut obliquely. Where the septa are small and not very distinct, the wood is much the strongest. The texture is alternately compact and porous; the compact part of the annual ring being of the darkest colors, and in irregular dots, surrounded by open pores, producing beautiful dark veins in some kinds, particularly pollard oaks. Oak timber has a particular smell, and the taste is slightly astringent. It contains gallic acid, and is blackened by contact with iron when it is damp. The young wood of English oak is very tough, often cross-grained, and difficult to work. Foreign wood, and that of old trees, is more brittle and workable. Oak warps and twists much in drying; and, in seasoning, shrinks about 1-32d of its width.

Oak of a good quality is more durable than any other wood that attains a like size. Vitruvius says it is of eternal duration when driven into the earth: it is extremely durable in water; and in a dry state it has been known to last nearly 1000 years. The more compact it is, and the smaller the pores are, the longer it will last; but the open, porous, and foxy-colored oak, which grows in Lincolnshire and some other places, is not near so durable.

Besides the common British oak (*Quercus robur*), the sessile-fruited bay-oak (*Quercus sessiliflora*) is pretty abundant in several parts of England, particularly in the north. The wood of this species is said by Tredgold to be darker, heavier, harder, and more elastic than the common oak; tough, and difficult to work; and very subject to warp and split in seasoning. Mr. Tredgold seems disposed to regard this species as superior to the common oak for shipbuilding. But other, and also very high authorities, are opposed to him on this point; and, on the whole, we should think that it is sufficiently well established that for all the great practical purposes to which oak timber is applied, and especially for shipbuilding, the wood of the common oak deserves to be preferred to every other species.

The oak is among the most useful productions of temperate climates, with the exception of a few on the mountainous parts of the equatorial regions. More than eighty species are known, of which one half inhabit North America, either within the territory of the United States, or on the mountains of Mexico. The white oak (*Q. alba*) is one of the most valuable. It extends from lat 46° to Florida, and from the Atlantic to a little west of the Mississippi. It attains the height of seventy or eighty feet, with a trunk six or seven in diameter. It is usual, after stripping the oak of its bark, to leave it standing for three or four years before it is cut for use. This species, and the *stillata*, are the species which furnish staves for casks, of which the consumption is immense. White oak timber is imported in immense quantities, from the ports of the Northern and Middle States; and that brought from Quebec is procured chiefly on the borders of Lake Champlain, in the states of New York and Vermont. It is also used for making the keels and knees of ships. The *Q. macrocarpa* is remarkable for the large size of the leaves and acorns, but the wood is of little value. The *Q. lyrata* is exclusively confined to wet swamps. The acorns are nearly covered by the cups. The timber is large and highly esteemed.

The live oak (*Q. virens*) is a tree of the very first importance. It is found growing along the Atlantic shores of the United States for 1600 miles, from Norfolk southwards. The leaves are evergreen, coriaceous, and entire. It does not usually attain greater height than forty or forty-five feet, with a trunk one or two in diameter, but the wide and branching summit furnishes knees of vessels. The wood is used for the naves and felloes of heavy wheels, for which purposes it is far superior to the white oak, as well as for screws and the cogs of mill-wheels. In the Southern States it is used for the frame-work of ships, and is looked on to be as durable as any European variety. The bark, too, is excellent for tanning. The black or quercitron oak (*Q. tinctoria*) is a large tree, found throughout the United States south of latitude 43°, and abundant in the Middle States. It is recognized by the yellow stain which it gives to the saliva on being chewed. The wood is reddish and coarse-grained, and is frequently substituted for white oak in building. It furnishes a large proportion of the red oak staves which are exported to the West Indies, and the bark is extensively employed in tanning. From the cellular integument *quercitron* is obtained—an article extensively employed in dyeing wool, silk, and paper-hangings, and which forms an important article of export from Philadelphia. The cork oak (*Q. suber*) furnishes the cork of commerce, which substance is the outer, thick, fungous covering of the bark, and is detached, at intervals of ten or twelve years, for as many as twelve or fifteen times, but after the fifth or sixth the quality degenerates. If not removed after a certain period, it splits and falls off, and is replaced by a new growth beneath. In some countries, where cork is abundant, the inhabitants use it for lining or covering their houses. When burnt in close vessels, a black powder is obtained, known under the name of *Spanish black*. The cork oak is cultivated in Spain, Portugal, and the south of France. It is best adapted to a dry, sandy, mountainous soil, and is never found in limestone districts.

To ascertain the strength of New Forest oak (English), a seasoned stick of timber was selected in April. From about midway between the centre and circumference of the tree, and beginning at about four feet from the ground end, a piece of very good and perfectly sound timber was cut, and reduced to the dimensions of five inches square, and eleven feet long. It was laid across two uprights; and a rough scale-like platform to contain the weight, formed of a very large plank, was suspended from the centre by a strong timber chain. Upon this platform, piece after piece was laid of hard Purbeck stone, until it became evident that there was sufficient to effect the fracture, and in a few seconds the whole fell to the ground. The stones employed were then weighed, and the weight of the platform and chain being added, it was found that the aggregate weight by which the object had been obtained, was 9061 pounds, or 4 tons, 3 quarters, and 17 pounds.

Oak bark, in the inner cortical of young trees, contains 77 of 111 of the tannin principle. The cellular, or middle, only 19 of 43, and the external part scarcely any tannin. In spring, the tannin is more than in winter. *See* TAN.

OAKUM is the substance into which old ropes are reduced when they are untwisted, loosened, and drawn asunder. It is principally used in calking the seams, tree-nails, and bends of a ship, for stopping or preventing leaks.

OAR. In nautical affairs, a long piece of timber, flat at one end, and round or square at the other, by which a boat, barge, or galley, &c., is propelled through the water. The flat part dipped into the water is called the *blade*; the other end is the *loom*, which terminates in the handle. The fulcrum of the oar is the hole in the gunwale called the *rowlock*, or between two pins called *thole pins*, or one thole pin with a loose strap for confining the oar. There are various nautical phrases contingent upon this term, a few of which may not, perhaps, be out of place here. *To boat the oars*, signifies to lay them in from rowing; *to feather the oar*, to hold the blade horizontally, so as not to catch the wind; *to lie on the oars*, to suspend rowing for any interval; this is also the salute given to persons of distinction in passing; to *ship* and *unship the oars*, respectively to fix and throw them out of the rowlocks.

OATS. The *avena sativa*. Natural family gramineæ. A gramineous plant characterised by a loose compound equal panicle and two-flowered spikelet. The oat is very extensively cultivated in most of the northern countries of Europe as a bread corn. It has long occupied the same place in Scotland that rye occupies in Germany and the potato in Ireland. In England it is chiefly used in the feeding of horses; but there, also, it is used to a considerable extent as food for man, particularly in the northern counties. There are leading varieties of the common oat cultivated in England—black; gray, dun-brown, or red; and white. The first two varieties being comparatively hardy, may be raised on very inferior soils, and in situations unsuitable for the other. The black is now, however, hardly known in England; but it is still cultivated to a considerable extent in some parts of the Highlands of Scotland, and in the Western Islands. The dun or red oat is principally confined to the moors of Cheshire, Derbyshire, and Staffordshire. White oats are, speaking generally, less hardy than either of the other varieties, and require a better soil, but they are also earlier, heavier, and yield a greater quanity of meal. There are numberless, and some widely different subvarieties of the white oat. That which is called the potato oat has long enjoyed the highest reputation in England, and is almost the only variety that is at present raised on good land in most parts of England and the south of Scotland. The produce of oats varies very greatly. When the ground is foul or exhausted, not more than 20 bushels an acre are obtained: but in a rich soil well managed, and in favorable years, 60, 70, and sometimes even 80 bushels and upwards have been reaped, weighing from 35 lbs. to 45 lbs. a bushel, and yielding 7 lbs. meal for 14 lbs. oats; but the proportion of meal increases as the oats become heavier.

In this country, on average soils, the yield is from 40 to 50 bushels, but on rich land, it goes up to 120 bushels. It is the common white oat which is most raised here. In Western New-York the black oat is preferred, and the Egyptian oat south of Tennessee. The latter rarely gives 20 bushels of ripe grain. It is by far the best food for working cattle or horses. There is a very good analysis of oats, made by Professor Norton, of New Haven. In nutritious properties it stands next to wheat, and above rye, barley, and rice.

OBJECT-GLASS (of a refracting telescope or microscope). The lens which first receives the rays of light coming directly from the object, and collects them into a focus, where they form an image which is viewed through the eye-glass.

The excellence of an object-glass depends on the distinctness of the image which it forms. On account of the unequal refrangibility of the rays of light, it is necessary, in order to procure a distinct image, to employ an achromatic combination of lenses, formed of substances having different dispersive powers, and of such figures that the aberration of the one may be corrected by that of the other. The substances chiefly used are crown-glass and flint-glass; the dispersive powers of which are respectively as 3 to 5. By combining a convex lens of crown-glass with a concave lens of flint-glass, having their focal distances in that proportion, an image would be formed free from color, but it would not be free from aberration. The determination of the form of the compound lens which shall give the least possible aberration for parallel rays is a problem which admits of exact calculation. The following are the dimensions found by Sir John Herschel for an object-glass of thirty inches focal length, the convex lens of which was of common glass, the outside towards the object, and the concave lens of flint-glass on the side next the eye: radius of the exterior surface of the crown lens, 20·0364 inches; radius of the exterior surface of the flint lens, 41·1687 inches; radii of the interior surfaces, 10·1604 and 10·1613 When the lenses have the forms here indicated, the focal lengths of each, separately, are in the direct ratio of their dispersive powers; and the two inside surfaces have so nearly the same curvature that they may be ground on the same tool, and united by a cement to prevent the loss of light at the two surfaces.

Such are the forms indicated by theory; but the practical difficulties of forming a good achromatic object-glass, for a telescope of large size, are so great that it often costs more than all the rest of the instrument. This, however, principally arises from the extreme difficulty of procuring disks of flint-glass, above a certain size, sufficiently free from veins and imperfections as to be fit for the purpose. No object-glasses of a larger size than seven inches diameter have been made of glass manufactured in England; and, notwithstanding the success of Fraunhofer at Munich, and of Guinaud in Switzerland, the procuring of flint-glass fit for object-lenses of a larger size seems to be still, in a considerable degree, a matter of accident. Fraunhofer executed a telescope for the Russian observatory at Dorpat, having an object-glass of 9 inches diameter. Another was prepared by him for the King of Bavaria, of 12 inches diameter. The object-glass of Sir James South's large telescope at the Campden Hill observatory is nearly 18 inches in diameter, and was executed in Paris of glass manufactured by Guinaud.

In the fine telescopes formerly constructed by Dollond, the object-glasses were composed of three lenses, the two exterior ones, being of crown-glass, and convex, and the interior of flint and concave. This combination gives a more perfect correction of the spherical abreration; but the advantage is more than balanced by the greater complexity of their construction, the risk of imperfect centering, and the loss of light at the six surfaces. They have accordingly been disused.

Various attempts have been made to dispense with the concave flint lens, by the substitution of some other refractive substance. Dr. Blair found that the dispersion of crown-glass was corrected by a fluid lens, composed of a mixture of solutions of ammoniacal and mercurial salts. He succeeded in making object-glasses in his manner, which at first gave promise of answering well; but it soon appeared that they were not durable, the fluid undergoing some chemical change which entirely destroyed its virtue. Professor Barlow, of Woolwich, has also made numerous experiments on this subject. His correcting lens is formed of the liquid sulphuret of carbon, inclosed between two disks of glass, and a ring of the same material, the fluid being introduced at a high temperature. A telescope which he made on this principle had a single object-lens of 7-8 inches, and the fluid lens was placed at the distance of 40 inches behind it. The performance of this telescope was, however, far inferior to an ordinary one of the same dimensions, with the common double achromatic object-glass. See LENS.

OBSIDIAN. A glassy lava, first mentioned by Pliny, as found in Ethiopia. It is of various colors, usually black, and nearly opaque; it is also called *volcanic glass*, and resembles the coarse slags of glass meltings. It is occasionally made into rings and cutting tools in Mexico and Peru. It is a fused silicate of alumina with a little potash and protoxide of iron.

OCHRE, an earth colored by some metallic oxide. Ochres are generally yellow, red, and brown; the tints are mostly produced by oxide of iron, and the darker tints are rendered bright by calcination. The earth from which ochre is formed contained originally either sulphuret of iron (pyrites), or silicate of iron, as in Basaltic rocks, which, decomposing, furnishes oxide of iron to color the clay. They are ground and used for out-door painting, and as a polishing substance.

ODOMETER (See PERAMBULATOR).

OIL. The term oil is applied to two dissimilar and distinct organic products, which are usually called *fixed* oils, and *volatile* oils. The fixed or fat oils are either of vegetable or animal origin; they are compounds of carbon, hydrogen, and oxygen; the relative proportions vary but little in the several species. The following analyses of olive and spermaceti oil may be assumed as types of the rest:

	Olive Oil.	Spermaceti Oil.
Carbon	772	780
Hydrogen	133	118
Oxygen	95	102
	1000	1000

The *fixed oils* abound in the fruit and seed of certain plants; they are lighter than water, unctuous, and insipid, or nearly so: some of these require a low temperature for their congelation, such as linseed oil; others, such as olive oil, concrete at a temperature higher than the freezing point of water; some are solid at common temperature, such as cocoa-nut oil. Some of these oils when exposed to air absorb oxygen, and gradually harden, forming a kind of varnish; these are called *drying oils*, and are the basis of paints, such as linseed oil; others become rancid, as almond oil. All these oils, like the different kinds of fat, consist of two proximate principles, called *stearine* and *elaine*—the former is the fatty portion, which first concretes on cooling the oil, and from which the elaine, or oily portion, may be separated by pressure. These oils cannot be volatilized without decomposition. At a red heat they are resolved into volatile and gaseous products, among which carburetted hydrogen, in several of its forms predominates; hence the use of these oils, when volatilized and burned by the aid of a wick, as sources of artificial light. The action of the alkali on the fat oils is highly important, as forming soap.

The *volatile oils* are generally obtained by distilling the vegetables, which afford them, with water; they fluctuate in density a little on either side of water; they are sparingly soluble in water, forming the perfumed or medicated waters, such as rose and peppermint water; they are mostly soluble in alcohol, forming essences. A few of them, such as oil of turpentine, of lemon peel, of copivi balsam, &c., are hydrocarbons, that is, consist of carbon and hydrogen only; the greater number, however, contain oxygen as one of their ultimate elements. They are chiefly used in medicine and in perfumery, and a few of them are extensively employed in the arts as vehicles for colors, and in the manufacture of varnishes; this is especially the case with oil of turpentine.

The fixed or fat oils are widely distributed through the organs of vegetable and animal nature. They are found in the seeds of many plants, associated with mucilage, especially in those of the dicotyledinous class, occasionally in the fleshy pulp surrounding some seeds, as the olive; also in the kernels of many fruits, as of the nut and almond tree, and finally in the roots, barks, and other parts of plants. In animal bodies, the oily matter occurs inclosed in thin membraneous cells, between the skin and the flesh, between the muscular fibres, within the abdominal cavity in the omentum, upon the intestines, and round the kidneys, and in a bony receptacle of the scull of the spermaceti whale; sometimes in special organs, as of the beaver; in the gall-bladder, &c., or mixed in a liquid state with other animal matters, as in the milk.

Braconnot, but particularly Raspail, have shown that animal fats consist of small microscopic, partly polygonal, and partly reniform particles, associated by means of their containing sacs. These may be separated from each other by tearing the recent fat asunder, rinsing it with water, and passing it through a sieve. The membranes being thus retained, the granular particles are observed to float in the water, and afterwards to separate, like the globules of starch, in a white pulverulent semi-crystaline form. The particles consist of a strong membraneous skin, inclosing *stearine* and *elaine*, or solid and liquid fat, which may be extracted by trituration and pressure. These are lighter than water, but sink readily in spirits of wine. When boiled in strong alcohol, the oily principle dissolves, but the fatty membrane remains. These granules have different sizes and shapes in different animals; in the calf, the ox, the sheep, they are polygonal, and from 1-70 to 1-450 of an inch in diameter; in the hog they are kidney-shaped, and from 1-70 to 1-140 of an inch; in man, they are polygonal, and from 1-70 to 1-900 of an inch; in insects they are usually spherical, and not more than 1-600 of an inch.

Dr. Ure, in his valuable dictionary of arts, &c., gives the following table of plants yielding fat oils of commerce:—

No.	Plants.	Oils.	Spec. gravit
1	Linum usitatissum et perenne........	Linseed oil	0·9347
2	Corylcus avellana	Nut oil.........................	0·9260
3	Juglans regia		
4	Papaver somniferum	Poppy oil	0·9243
5	Cannabis sativa......................	Hemp oil......................	0·9276
6	Sesamum orientale	Oil of sesamum................	
7	Olea Europea	Olive oil.	0·9176
8	Amygdalus communis	Almond oil	0·9180
9	Guilandina mohringa	Oil of behen or ben	
10	Cucurbita pepo, and melapepo.......	Cucumber oil..................	0·9231
11	Fagus silvatica	Beech oil......................	0 9225
12	Sinapis nigra et arvensis	Oil of mustard................	0·9160
13	Helianthus annuus et perennis	Oil of sunflower	0 9262
14	Brassica napus et campestris.........	Rape-seed oil..................	0·9136
15	Ricinus communis	Castor oil......................	0·9611
16	Nicotiana tabacum et rustica.........	Tobacco-seed oil...............	0·9232
17	Prunus domestica....................	Plum-kernel oil................	0·9127
18	Vitis vinifera	Grape-seed oil.................	0·9202
19	Theobroma cacao....................	Butter of cacao	0·8920
20	Cocos nucifera	Cocoa-nut oil..................	
21	Cocus butyracea vel avoira elais......	Palm-oil.......................	0·9680
22	Laurus nobilis.......................	Laurel-oil	
23	Arachis hypogæa	Ground-nut oil.................	
24	Vateria indica	Piney tallow...................	0·9260
25	Hesperis matronalis	Oil of Julienne	0·9281
26	Myagrum sativa......................	Oil of camelina................	0·9252
27	Reseda luteola.......................	Oil of weld-seed	0·9358
28	Lepidium sativum....................	Oil of garden cresses...........	0·9240
29	Atropa belladonna	Oil of deadly nightshade	0·9250
30	Gossypium Barbadense..............	Cotton-seed oil	
31	Brassica campestris oleifera..........	Colza oil	0·9136
32	Brassica præcox......................	Summer rape-seed oil..........	0 9139
33	Raphanus sativus oleifer.............	Oil of radish-seed	0·9187
34	Prunus cerasus.......................	Cherry-stone oil	0 9239
35	Pyrus malus	Apple-seed oil	
36	Euonymus Europæus.................	Spindle-tree oil	0·9380
37	Cornus sanguinea	Cornil-berry tree oil............	
38	Cyperus esculenta....................	Oil of the roots of cyper grass...	0·9180
39	Hyociamus niger	Henbane seed oil	0·9130
40	Æsculus hippocastanum.............	Horse chesnut oil	0·9270
41	Pinus abies..........................	Pinetop oil	0 2850

The fat oils are contained in that part of the seed which gives birth to the cotyledons; they are not found in the plumula and radicle. Of all the families of plants, the cruciform is the richest in oleiferous seeds; and next to that are the drupaceæ, amentaceæ, and solaneæ. The seeds of the gramineæ and leguminosæ contain rarely more than a trace of fat oil. One root alone, that of the *cyperus esculenta*, contains a fat oil. The quantity of oil furnished by seeds varies not only with the species, but in the same seed, with culture and climate. Nuts contain about half their weight of oil; the seeds of the *brassica oleracea and campestris*, one third; the variety called colza in France, two fifths; hempseed, one fourth; and linseed from one fourth to one fifth. Unverdorben states that a last or ten quarters of linseed yields 40 ahms=120 gallons of oil; which is about 1 cwt. of oil per quarter.

The fat oils, when first expressed without much heat, taste merely unctuous on the tongue, and exhale the odor of their respective plants. They appear quite neutral by litmus paper. Their fluidity is very various, some being solid at ordinary temperatures, and others remaining fluid at the freezing point of water. Linseed oil indeed does not congeal till cooled from 4° to 18° below 0° F. The same kind of seed usually affords oils of different degrees of fusibility; so that in the progress of refrigeration one portion concretes before another. Chevreul, who was the first to observe this fact, considers all the oils to be composed of two species, one of which resembles *suet*, and was thence styled by him *stearine;* and another which is liquid at ordinary temperatures, and was called *elaine*, or *oleine*. By refrigeration and pressure between the folds of blotting paper, or in linen bags, the fluid part is separated, and the solid remains. By heating the paper in water, the liquid oil may be obtained separate. When alcohol is boiled with the natural oil, the greater part of the stearine remains undissolved.

Oleine may also be procured by digesting the oil with a quantity of caustic soda, equal to one half of what is requisite to saponify the whole; the stearine is first transformed into soap, then a portion of the oleine undergoes the same change, but a great part of it remains in a pure state. This process succeeds only with recently expressed or very fresh oils. The properties of these two principles of the fat oils vary with the nature of the respective oils, so that the sole difference does not consist, as many suppose, in the different proportions of these two bodies, but also in peculiarities of the several stearines and oleines, which, as extracted from different seeds, solidify at very different temperatures.

In close vessels, oils may be preserved fresh for a very long time, but with contact of air they undergo progressive changes. Certain oils thicken and eventually dry into a transparent, yellowish, flexible substance; which forms a skin upon the surface of the oil, and retards its further alteration. Such oils are said to be *drying* or *siccative*, and are used on this account in the preparation of varnishes and painter's colors. Other oils do not grow dry, though they turn thick, become less combustible, and assume an offensive smell. They are then called *rancid*. In this state they exhibit an acid reaction, and irritate the fauces when swallowed, in consequence of the presence of a peculiar acid, which may be removed in a great measure by boiling the oil along with water and a little common magnesia for a quarter of an hour, or till it has lost the property of reddening litmus. While oils undergo the above changes, they absorb a quantity of oxygen equal to several times their volume. Saussure found that a layer of nut oil, one quarter of an inch thick, inclosed along with oxygen gas over the surface of quicksilver in the shade, absorbed only three times its bulk of that gas in the course of eight months; but when exposed to the sun in August, it absorbed 60 volumes additional in the course of ten days. This absorption of oxygen diminished progressively, and stopped altogether at the end of three months, when it had amounted to 145 times the bulk of the oil. No water was generated, but 21·9 volumes of carbonic acid were disengaged, while the oil was transformed in an anomalous manner into a gelatinous mass, which did not stain paper. To a like absorption we may ascribe the elevation of temperature which happens when wool or hemp, besmeared with olive or rapeseed oil, is left in a heap; circumstances under which it has frequently taken fire, and caused the destruction of both cloth-mills and dockyards.

In illustration of these accidents, if paper, linen, tow, wool, cotton, mats, straw, wood shavings, moss, or soot, be imbued slightly with linseed or hempseed oil, and placed in contact with the sun and air, especially when wrapped or piled in a heap, they very soon become spontaneously hot, emit smoke, and finally burst into flames. If linseed oil and ground manganese be triturated together, the soft lump so formed will speedily become firm, and ere long take fire.

The fat oils are completely insoluble in water. When agitated with it, the mixture becomes turbid, but if it be allowed to settle, the oil collects by itself upon the surface. This method of washing is often employed to purify oils. Oils are little soluble in alcohol, except at high temperatures. Caster oil is the only one which dissolves in cold alcohol. Ether, however, is an excellent solvent of oils, and is therefore employed to extract them from other bodies in analysis; after which it is withdrawn by distillation.

Fat oils may be exposed to a considerably high temperature, without undergoing much alteration; but when they are raised to nearly their boiling point, they begin to be decomposed. The vapors that then rise are not the oil itself, but certain products generated in it by the heat. These changes begin somewhere under 600° of Fahr., and require for their continuance temperatures always increasing. The products consist at first in aqueous vapor, then a very inflammable volatile oil, which causes boiling oil to take fire spontaneously; and next carbureted hydrogen gas, with carbonic acid gas. In a lamp, a small portion of oil is raised in the wick by capillarity, which being heated, boils and burns. (*See* Rosin-Gas.)

Several fat oils, mixed with one or two per cent. of sulphuric acid, assume instantly a dark green or brown hue, and, when allowed to stand quietly, deposit a coloring matter after some time. It consists in a chemical combination of the sulphuric acid, with a body thus separated from the oil, which becomes in consequence more limpid, and burns with a brighter flame, especially after it is washed with steam, and clarified by repose or filtration. Any remaining moisture may be expelled by the heat of a water bath.

The oils combine with the salifiable bases, and give birth to the substance called *glycerine*, (the sweet principle,) and to the margaric, oleic, and stearic acids. The general product of their combination with potash or soda, is Soap, which see. Caustic ammonia changes the oils very difficultly and slowly into a soap; but it readily unites with them into a milky emulsion called volatile liniment, used as a rubefacient in medicine. Upon mixing water with this liquor, the oil separates in an unchanged state. By longer contact, ammonia acts upon oils like the other alkalies. Sea-salt dissolves in small quantity in the oils, and so does verdigris. The latter solution is green. Oils dissolve also several of the vegetable alkalies, as morphia, cinchonia, quinia, strychia, and delphia.

The following is the chemical composition of a few of the fixed oils:—

	Carbon.	Hydrogen.	Oxygen.	Azote.	
Castor oil	74·00	10·30	15·70		
Stearine of olive oil	82.17	11·23	6·30	0·30	*Saussure.*
Oleine of do	76·03	11·54	12·07	0·35	do.
Linseed oil	76·01	11·35	12·64		do.
Nut oil	79·77	10·57	9·12	0·54	do.
Oil of almonds	77·40	11·48	10·83	0·29	

De Saussure concludes that the less fusible fats contain more carbon and less oxygen, and that oils are more soluble in alchohol, the more oxygen they contain.

Oil of almonds, according to Gusseron, contains no stearine; at least he could obtain none by cooling it and squeezing it successively till it all congealed.

Oil of colza is obtained from the seeds of *brassica campestris*, to the amount of 39 per cent. of their weight. It forms an excellent lamp oil, and is much employed in France.

The *corylus avellana* furnishes in oil 60 per cent. of the weight of the nuts.

Hempseed oil resembles the preceding, but has a disagreeable smell, and a mawkish taste. It is used extensively for making both soft soap and varnishes.

Linseed oil is obtained in greatest purity by cold pressure; but, by a steam heat of about 200° F., a very good oil may be procured in larger quantity. The proportion of oil usually stated by authors is 22 per cent. of the weight of the seed; but by hydraulic pressure, from 26 to 27 is obtained. It dissolves in 5 parts of boiling alcohol, in 40 parts of cold alcohol, and in 1·6 parts of ether. When kept long cool in a cask partly open, it deposits masses of white stearine along with a brownish powder. That stearine is very difficult of saponification.

Mustard-seed oil. The white or yellow seed affords 36 per cent. of oil, and the black seed 18 per cent. The oil concretes when cooled a little below 32° F.

Nut oil is at first greenish colored, but becomes pale yellow by time. It congeals at the same low temperature as linseed oil, into a white mass, and has a more drying quality than it.

Oil of olives is sometimes of a greenish, and at others of a pale yellow color. It is prepared from ripe olives, gathered late in autumn. The pulp is separated from the kernels by passing them between stones: they are then pressed in rush bags: its specific gravity is 915. A few degrees above 32° F. it begins to deposit some white granules of stearine, especially if the oil have been originally expressed with heat. At 22° it deposits 28 per cent. of its weight in stearine, which is fusible again at 68°, and affords 72 per cent. of oleine. According to Kerwych, oleine of singular beauty may be obtained by mixing 2 parts of olive oil with 1 part of caustic soda ley, and macerating the mixture for 24 hours with frequent agitation. Weak alcohol must then be poured into it, to dissolve the stearine soap, whereby the oleine, which remains meanwhile unsaponified, is separated, and floats on the surface of the liquid. This being drawn off, a fresh quantity of spirits is to be poured in, till the separation of all the oleine be completed. It has a slightly yellowish tint, which may be removed by means of a little animal charcoal mixed with it in a warm place for 24 hours. By subsequent filtration, the oleine is obtained limpid and colorless, of such quality that it does not thicken with the greatest cold, nor does it affect either iron or copper instruments immersed in it.

There are three kinds of olive oil in the market. The best, called virgin salad oil, is obtained by a gentle pressure in the cold; the more common sort is procured by stronger pressure, aided with the heat of boiling water; and thirdly, an inferior kind, by boiling the olive residuum, or *marc*, with water, whereby a good deal of mucilaginous oil rises and floats on the surface. The latter serves chiefly for making soaps. A still worse oil is got by allowing the mass of bruised olives to ferment before subjecting it to pressure.

Oil of olives is refined for the watchmakers by the following simple process: Into a bottle or vial containing it, a slip of sheet lead is immersed, and the bottle is placed at a window, where it may receive the rays of the sun. The oil by degrees gets covered with a curdy mass, which after some time settles to the bottom, while itself becomes limpid and colorless. As soon as the lead ceases to separate any more of that white substance, the oil is decanted off into another vial for use.

Palm oil melts at 117·5° F., and is said to consist of 31 parts of stearine and 69 of oleine in 100. It becomes readily rancid by exposure to air, and is whitened at the same time.

The oil extracted from the plucked tops of the *pinus abies*, in the Black Forest in Germany, is limpid, of a golden yellow color, and resembles in smell and taste the oil of turpentine. It answers well for the preparation of varnishes.

Poppy-seed oil has none of the narcotic properties of the poppy juice. It is soluble in ether in every proportion.

Rape-seed oil has a yellow color, and a peculiar smell. At 25° F. it becomes a yellow mass, consisting of 46 parts of stearine, which fuses at 50°, and 54 of oleine, in which the smell resides.

The sun-flower is largely cultivated in this country, for the sake of the oil. An acre yields from 60 to 75 bushels, and every bushel gives a gallon of oil. The oil-cake is a fine fattener for cattle.

Oil of almonds is manufactured by agitating the kernels in bags, so as to separate their brown skins, grinding them in a mill, then enclosing them in bags, and squeezing them strongly between a series of cast iron plates, in a hydraulic press; without heat at first, and then between heated plates. The first oil is the purest, and least apt to become rancid. It should be refined by filtering through porous paper. Next to olive oil, this species is the most easy to saponify. Bitter almonds, being cheaper than the sweet, are used in preference for obtaining this oil, and they afford an article equally bland, wholesome, and inodorous. But a strongly scented oil may be procured, according to M. Planché, by macerating the almonds in hot water, so as to blanch them, then drying them in a stove, and afterwards subjecting them to pressure. The volatile oil of almonds is obtained by distilling the marc or bitter almond cake, along with water.

Linseed, rapeseed, poppyseed, and other oleiferous seeds were formerly treated for the extraction of their oil, by pounding in hard wooden mortars with pestles shod with iron, set in motion by cams driven by a shaft turned with horse or water power, then the triturated seed was put into woollen bags which were wrapped up in hair-cloths, and squeezed between upright wedges in press-boxes by the impulsion of vertical rams driven also by a cam mechanism. In the best mills upon the old construction, the cakes obtained by this first wedge pressure were thrown upon the bed of an edge-mill, ground anew and subjected to a second pressure, aided by heat now, as in the first case. These mortars and press-boxes constitute what are called Dutch mills.

A good oil for chronometers is a great

desideratum. The following has been tried, and is much used:—Having procured good olive oil, put about one gallon into a cast-iron vessel capable of holding two gallons; place it over a slow, clear fire, keeping a thermometer suspended in it; and, when the temperature rises to 920°, check the heat, never allowing it to exceed 230°, nor descend below 212°, for one hour; by which time the whole of the water and acetic acid will be evaporated. The oil is then exposed to a temperature of 80° to 86°, for two or three days. By this operation, a considerable portion is congealed; and, while in this state, pour the whole on a muslin filter, to allow the fluid portion to run through; the solid, when re-dissolved, may be used for common purposes. Lastly, the fluid portion must be filtered, once or more, through newly-prepared animal charcoal, grossly powdered, or rather broken, and placed on bibulous paper in a wire-frame, within a funnel: by which operation rancidity (if any be present) is entirely removed, and the oil is rendered perfectly bright and colorless.

Oil, for delicate machinery, should be purified from its stearine, or fatty matter, which is effected by gradually boiling it with eight times its weight of alcohol. When cold, the stearine separates in a precipitate, and the liquid is to be evaporated to a fifth, which is pure elaine, or oil, without any chemical action or odour.

Oils in painting afterward fatten and do not dry, owing either to want of combination in the pigment, or to the oil not being old enough. Olive oil, for example, will not dry—even several samples vary in this defect. Keeping, and the use of some drying substance, are the best remedies. Oils are adopted because they give an equal surface and a subsequent body.

Drying oils, by boiling, or sometimes by setting on fire, by which they cease to stain paper, are linseed, walnut, hemp, poppy, castor, croton, grapeseed, nightshade, tobacco, henbane, sun-flower, and cress.

Drying oils are best prepared by boiling a gallon of linseed oil with 1¼ lb. of red lead, and leaving it to stand till the lead has subsided. Other materials effect the same purpose, as white vitriol, sugar of lead, gum mastic, &c., where long boiling is inconvenient. *Or*, take half a gallon of linseed oil, and slowly boil it with 6 oz. of litharge, and 1¼ of white vitriol, till no more scum arises. Let it cool and settle, and then pour off the clear into small vessels, and in ten days it will be fit for use. *Or*, suspending in boiling oil a bag of litharge and white vitriol for 4 or 5 hours. *Or*, well stir a lb. of white lead with a gallon of linseed oil, and leave it to settle for 8 or 10 days.

Fat oils generally may acquire a drying quality by the following treatment:—Take of nut oil, or linseed oil, 8 lbs.; white lead, slightly calcined; sugar of lead, also calcined; white vitriol: of each 1 oz. Litharge, 12 oz., a head of garlic, or a small onion. When these are pulverized, mix them with the garlic and oil over a fire capable of maintaining the oil in a slight state of ebullition: continue it till the oil ceases to throw up scum, assumes a reddish color, and the garlic, or onion, becomes brown. A pellicle indicates that the operation is completed. Take the vessel from the fire, and the pellicle, precipitated by rest, will carry with it the unctuous parts. When the oil becomes clear, separate it from the deposit, and put it into wide-mouthed bottles, where it will completely clarify itself.

In all cases, where preparations of lead are employed for freeing oils from greasy principles, the mixture should not be stirred. It is sufficient to leave the mixture over a gentle fire, capable of producing slight ebullition. The garlic merely indicates the moment when the aqueous part is evaporated.

Drying oil is employed by those who paint pictures, and it enters into the composition of varnishes. It serves itself also as varnish, either employed alone, or diluted with oil of turpentine.

For house painting, it is advantageous to use, for the last coating, *resinous drying oil*, as a varnish. It is prepared as follows:—Take 10 lbs. of drying nut oil, if the paint be designed for external surfaces, or 10 lbs. of drying linseed oil, if for internal. Yellow resin 3 lbs., common turpentine 6 oz. Melt the resin, to which add the turpentine, and lastly, the oil, so as not to coagulate the resin; leave the varnish at rest, by which means it will often deposit portions of resin and other impurities; preserve it in wide-mouthed bottles. It must be used fresh: when suffered to grow old, it deposits some of its resin. If this resinous oil become too thick, dilute it with a little oil of turpentine, or with oil of poppy, if intended for articles sheltered from the sun.

OIL GAS. The inflammable gases and vapors (chiefly *hydrocarbons*) which are obtained by passing fixed oils through red-hot tubes, and which may be used as *coal gas*, for the purposes of illumination; it yields a more brilliant light than the latter; but is, in most instances, too expensive to be generally adopted. Brande states that a gallon of common whale oil yields from 90 to 100 cubical feet of gas; and an Argand burner, giving the light of six or seven wax candles, consumes from 1½ to 2 cubical feet per hour; whereas, to produce the same light, from 5 to 6 cubic feet of coal gas are required. Another estimate is given below.

Purified oil is never used, as gas can be obtained from impure oils, train oil, or refuse feet, with as much ease as from the purer kinds. It is a good means for using up such materials. The results obtained by Henry, show the following results in 100 parts of illuminating gas:—

Substance distilled.	Temperature of distillation.	Spec. grav. of the gas.	Absorbed by chlorine.	Light carburetted hydrogen.	Carbonic oxide.	Hydrogen.	Nitrogen.
Oil............	Bright red heat.......	0·464	6	28·2	14·1	45·1	6·6
	Do.	0·590	19	32·4	12·2	32·4	4
	Lowest possible heat..	0·758	22·5	50·3	15·5	7·7	4
Train oil.........	Low red heat.........	0·906	38·	46·5	9·5	3·	3

From the above, it appears that oil gas is superior to that obtained from coal, as shown by its gravity, and that the produce is of the best quality when obtained at a low red heat. This temperature is sufficient to convert the oil into gas, but is not sufficiently high to decarbonize the gas to any great extent. The apparatus for obtaining gas is simple: a retort is filled with bricks, or lumps of coke, so as to extend the surface when heated. The oils flow in a thin and constant stream upon the red hot bricks, when it is almost immediately purified; the gas is carried on to the hydraulic main, and from thence through the purifiers to the gasometer. Cast iron retorts are used; and 1 cubic foot, or 4 gallons of oil, produce from 600 to 700 cubic feet of gas, which is equivalent to from 90 to 96 per cent. by weight. The remainder is deposited carbon. Oil gas contains much more olefiant gas and naptha vapors than coal gas, and is hence more valuable as an illuminating agent.

OIL OF BRICKS. A term applied by the old chemists to the empyreumatic oil obtained by subjecting a brick which has been soaked in oil to the process of distillation at a high temperature. The oil is used by lapidaries as a vehicle for the emery by which stones and gems are sawn or cut.

OILS, VOLATILE OR ESSENTIAL; Manufacture of. The volatile oils occur in every part of oderiferous plants, whose aroma they diffuse by their exhalation; but in different organs of different species. Certain plants, such as thyme and the scented *labiatæ*, in general contain volatile oil in all their parts; but others contain it only in the blossoms, the seeds, the leaves, the root, or the bark. It sometimes happens that different parts of the same plant contain different oils; the orange, for example, furnishes three different oils, one of which resides in the flowers, another in the leaves, and a third in the skin or epidermis of the fruit. The qantity of oil varies not only with the species, but also in the same plant, with the soil, and especially the climate; thus in hot countries it is generated most profusely. In several plants, the volatile oil is contained in peculiar orders of vessels, which confine it so closely that it does not escape in the drying, nor is dissipated by keeping the plants for many years. In other species, and particularly in flowers, it is formed continually upon their surface, and flies off at the moment of its formation.

Volatile oils are usually obtained by distillation. For this purpose the plant is introduced into a still, water is poured upon it, and heat being applied, the oil is volatilized by the aid of the watery vapor, at the temperature of 212°, though when alone it would probably not distil over unless the heat were 100° more. When the mingled vapors of the oil and water are condensed into the liquid state, by the refrigerator of the still, the oil separates, and either floats on the surface or sinks to the bottom of the water. Some oils of a less volatile nature require a higher heat than 212° to raise them in vapor, and must be dislodged by adding common salt to the water, whereby the heat being augmented by 15°, they readily come over.

There are a few essential oils which may be obtained by expression, from the substances which contain them; such as the oils of lemons and bergamot, found in the pellicle of the ripe fruits of the *citrus aurantium* and *medica;* or the orange and the citron. The oil comes out in this case with the juice of the peel, and collects upon its surface.

For collecting the oils of odoriferous flowers which have no peculiar organs for imprisoning them, and therefore speedily let them exhale, such as violets, jasmine, tuberose, and hyacinth, another process must be resorted to. Alternate layers are formed of the fresh flowers, and thin cotton fleece, or woollen cloth-wadding, previously soaked in a pure and inodorous fat oil. Whenever the flowers have given out all their volatile oil to the fixed oil upon the fibrous matter, they are replaced by fresh flowers in succession, till the fat oil has become saturated with the odorous particles. The cotton or wool wadding being next submitted to distillation along with water, gives up the volatile oil. Perfumers alone use these oils; they employ them either mixed as above, or dissolve them out by means of alcohol. In order to extract the oils of certain flowers, as for instance of white lilies, infusion in a fat oil is sufficient.

Essential oils differ much from each other in their physical properties. Most of them are yellow, others are colorless, red, or brown; some again are green, and a few are blue. They have a powerful smell, more or less agreeable, which immediately after their distillation is occasionally a little rank, but becomes less so by keeping. The odor is seldom as pleasant as that of the recent plant. Their taste is acrid, irritating, and heating, or merely aromatic when they are largely diluted with water or other substances. They are not greasy to the touch, like the fat oils, but on the contrary make the skin feel rough. They are almost all lighter than water, only a very few falling to the bottom of this liquid; their specific gravity lies between 0·847 and 1.096; the first number denoting the density of oil of citron, and the second that of oil of sassafras. Although, when exposed to the air, the volatile oils change their color, become darker, and gradually absorb oxygen. This absorption commences whenever they are extracted from the plant containing them; it is at first considerable, and diminishes in rapidity as it goes on. Light contributes powerfully to this action, during which the oil disengages a little carbonic acid, but much less than the oxygen absorbed; no water is formed. The oil turns gradually thicker, loses its smell, and is transformed into a resin, which becomes eventually hard. De Saussure found that oil of lavender recently distilled had absorbed in four months, and at a temperature below 54° F., 52 times its volume of oxygen, and had disengaged twice its volume of carbonic acid gases; nor was it yet completely saturated with oxygen. The stearessence of anise-seed oil absorbed at its liquefying temperature, in the space of two years, 156 times its volume of oxygen gas, and disengages 26 times its volume of carbonic acid gas. An oil which has begun to experience such an oxydizement is composed of a resin dissolved in the unaltered oil; and the oil may be separated by distilling the solution along with water. To preserve oils in an unchanged state, they must be put in vials, filled to the top, closed with ground glass stopples, and placed in the dark.

Volatile oils are little soluble in water, yet enough so as to impart to it by agitation their characteristic smell and taste. The water which distils with any oil is in general a saturated solution of it, and as such is used in medicine under the name of distilled water.

The principal volatile or essential oils are those of turpentine, aniseed, nutmeg, lavender, cloves, caraway, peppermint, spearmint, sassafras, camomile, and citron. The taste is acrid and burning; and the odor very pungent, resembling the taste and smell of the vegetables. They boil at a temperature considerably above that of boiling water; thus, oil of turpentine boils at 315°. They are soluble in strong alcohol, but, on adding water, are precipitated. They are soluble in ether in like manner, but do not form soaps with alkalies, *by which they are distinguished from the fixed oils.* They are readily inflamed by strong nitric acid; especially if a little sulphuric acid be added, to render the acid more concentrated. Exposed to the action of the air, they undergo an alteration in consequence of the absorption of oxygen, become thickened, and gradually change into a solid matter, resembling resins.

When digested with sulphur, they unite with it, forming *balsam of sulphur*.

One of the most useful is that of turpentine, called *spirit of turpentine*. It is obtained by distilling turpentine and water, in due proportions, in a copper alembic. It is the solvent employed in making a variety of varnishes, but it requires to be rectified by a second distillation.

In general, volatile oils are used in pharmacy or as perfumes. Those applied to the latter use, are the essence of roses, of jasmine, violets, &c., but require much care in preparation. This is best done by spreading upon white wool, impregnated with olive oil, the petals of the flowers, and leaving them for some time, covered over with a woollen cloth, upon which flowers are also scattered. The flowers are renewed from time to time, until the olive-oil employed appears to be saturated with the oil of the flowers, and this last is then separated by digesting the wool in alcohol.

Essential oils, as previously mentioned, are obtained by distilling the basis with an equal weight of water to prevent them from adhering to the still, and the oil and water acquiring a burnt taste; some, as those of the peels of fresh fruits, are obtained by rasping them, and pressing the raspings; a few by distilling the articles with twice their weight of water, adding 1 lb. of salt to each gallon of water, using a quick fire, and when half the water has come over, pouring it back again into the still, and thus cohobating it. When rectified, for the purpose of rendering them finer, they are distilled without water in a retort, and one half the oil is drawn over. They are all stimulant, in doses of 2 to 10 drops upon sugar, but are mostly made into cordial waters, by distilling with spirit of wine, or water. The following are some of the principal, for they consist of 2 or 300.

Oil of Wormwood—25 lbs. of green wormwood yielding from 6 to 10 drs. of this oil. *Oil of Acorns*—50 lbs. yield 2 oz. *Essential oil of bitter Almonds*—from ground almond cake, by distillation, with twice as much water and half as much salt, after having been left to soak for some days, and when half the water is come over, pouring it back into the still: 25 lbs. of cake yield 2 oz. and contains prussic acid; when rectified, its strength is prodigiously increased. *Oil of Anise-seeds*—from the seeds; congeals at 62°. *Oil of Star Anise-seeds*—from the capsules, very fragrant. *Oil of Dill-seed*—Carminative. *Essence of Bergamotte*—from the peels of the Bergamotte orange; by pressure, very fragrant. *Huile d'orange*—from orange-peel, by pressure; very fragrant. *Cajeput oil*—from the leaves. *Oil of Carui*—from the seeds, carminative. *Oil of Cloves*—from cloves, soaked and distilled with salt-water, the distilled water being returned two or three times into the still; very heavy and acrimonious. *Distilled oil of Camomile Flowers*—from the flowers, stomachic. *Oil of Cinnamon*—from the fresh bark, distilled with sea-water. *Rectified oil of Citrons*—the pressed oil of the whole peels, distilled until 3 oz. out of 5 are come over, white, very fragrant. *Oil of Cummin-seed*—*Oil of Hops*—Collected during the boiling of hops in beer. *Essences des Violettes*—from the root of Florentine orris; smells like violets. *Essence of Jasmine*—from the flowers of Jasminium grandiflorum, highly fragrant. *Oil of Lavender*—from the flowers of narrow-leaved lavender, very fine scented. *Oil of Spike*—from the flowers and seeds of French lavender. *Rectified oil of Lavender*—drawing off 3 oz. in 5; used for choice perfumery. *Riga Balsam*—from the shoots of Pinus cembra, previously bruised and macerated for a month in water; vulnerary, diuretic. *Essence of Lemons*—from the fresh peels of lemons; limpid, watery, fragrant; used in perfumery. *Oil of Mace*—from that spice. *Oil of sweet Marjoram*.—*Oil of Peppermint*—from the dried plant, 4 lbs. of the fresh herb yielded 3 drs.; used to flavor spirit. *Rectified oil of Peppermint*—used for peppermint lozenges and drops, very warm. *Oil of Milfoil*—18 baskets yield 4 oz. 4 drs. *Essence of Myrtle*—from the flowers and leaves; fragrant. *Essence of Jonquil*—used in perfumery. *Oil of Nutmeg*—from that spice. *Oil of Thyme*—from the plant, 2 cwt. fresh yield 54 oz. stimulant, makes the hair grow, used in tooth-ache. *Oil of Pimento*—from allspice. *Oil of Penny-royal*—from the herb when in flower. *Oil of Ravensara*—from the leaves; sold for oil of cloves. *Oil of Rhodium*—from Levant lignum rhodium: 80 lbs. yielded 9 drs. *Oil of Roses*—from the flowers of musk roses in the cups split open, soaked in twice their weight of salt-water for several days, then distilled, and the water cohobated once or twice on them: 1 cwt. yields from half an oz. to an oz. of oil. *Attar of Roses*—from the evergreen rose and the musk rose, the newly-distilled rose-water being exposed to the night air; a highly-esteemed perfume; freezes at 50°, melts at 85°. *Oil of Rosemary*—from the flowering tops; sweet scented. *Rectified oil of Rosemary*—by redistilling until one-half is come over, and used for fine perfumery. *Oil of Rue*—from the dried plant, carminative, antispasmodic. *Oil of Savine*—from the dried plant, stimulant and powerfully emmenagogue; externally rubefacient. *Oil of Sandal-wood*—1 lb. yields 2 drs. It is sold for oil of rhodium, and oil of roses. *Oil of Sassafras*—from the root of sassafras, with salt-water, and cohobation. *Oil of Lemon Thyme*—used to scent soaps. *Oil of Tansey*—from the herb. *Oil of Thyme*—2 cwt. fresh flowers yield 5¼ oz. *Oil of Turpentine*—from rough turpentine distilled with an equal weight of water.

OIL MILLS, or PRESSION MILLS, are moved by horse, or water power, in Holland by wind, and in England often, and in this country almost always, by steam. The object is to unite weight of pressure with percussion, and therefore obtain oil from seeds. The principle is that of the pile engine, the falling with acceleration of a heavy loaded beam on a bag of seed, so placed as that its oil will exude into receptacles beneath. A wheel called a walloper, provided with wipers, or projections, is turned by the spur and treadle, and the wipers catch and lift the beams, or pestles, which being unattached by the rotation of the wheel fall with force on the seed, which has usually been rolled and expressed previously. The oil paste, or cakes, left after pressing, is excellent food for cattle. The French vegetable oils produce the whitest and clearest light known, equal to the best carburetted hydrogen gas.

The quantities of volatile oil, obtained from different vegetables, are:—

Aniseed	1 lb.	2 drs.
Assafœtida	4 oz.	1 dr.
Cajeput seeds	1 lb.	15 grs.
Camomile flowers, common	1 lb.	¼ dr.
Caraway seeds	4 lbs.	2 oz.
Cardamum seeds	1 oz.	1 scr.
Carrot seeds	2 lbs.	1¼ dr.
Cinnamon	1 lb.	1 dr.
Cloves	1 lb.	1¼ oz.
Copaiba balsam	1 lb.	6 oz.
Cummin seed	1 lb.	5 drs.
Dill seed	4 lbs.	2 oz.
Juniper berries	8 lbs.	3 oz.
Lavender, in flower, fresh	48 lbs.	12 oz.
Mace	1 lb.	5 drs.
Marjoram, in flower, fresh	85 lbs.	3 oz.
Nutmegs	1 lb.	1 oz.
Roses	1 cwt.	1 oz.
Rosemary, in flower	1 cwt.	8 oz.
Sage leaves	34 lbs.	1½ oz.
Sassafras wood	6 lbs.	1¾ oz.
Savin bark	2 lbs.	5 oz.
Thyme, in flower, fresh	2 cwt.	5¼ oz

According to experiments, the following species of plants yield per cent. of oil:—

Filberts	60
Garden cress	56 to 58
Olive	50
Walnut	50
Poppy	47 to 50
Almond	46
Navew	39
White Mustard	36
Tobacco seed	32 to 36
Kernels of plums	33
Winter rape	33
Summer rape	30
Woad	30
Camelina	28
Hemp seed	25
Fir	24
Linseed	22
Black mustard	18
Heliotrope	15
Beech masts	12 to 16
Grape stones	10 to 11

OIL OF VITROIL, concentrated SULPHURIC ACID.

OISANITE. An ore of Titanium, found in the department Oise, France.

OLD RED SANDSTONE. A series of rocks interposed between the carboniferous limestone and the slate. They correspond to the Potsdam sandstone of the New-York Geological Survey Report, are chiefly siliceous, much used for building churches in New-York and other cities, and are highly interesting from the fossils and fossil marks which are found in them.

OLEFIANT GAS. This variety of carburetted hydrogen is obtained by heating a mixture of two measures of sulphuric acid and one of alcohol. It is of somewhat less specific gravity than atmospheric air, 100 cubic inches weighing 30·5 grs. It burns with a bright white flame, and produces during combustion such proportions of carbonic acid and water as show that 1 volume of the gas is constituted of 2 atoms or volumes of hydrogen and 2 atoms of carbon; hence the equivalent of olefiant gas is $(2\,h + 12\,car.) = 14$. When two volumes of chlorine are mixed with 1 of olefiant gas, and inflamed, hydrocholoric acid is formed, and the charcoal of the gas makes its appearance in the form of dense black soot. If the mixture, instead of being kindled, be left standing over water, it soon condenses into a liquid looking like oil (hence the term *olefiant gas*), which is hydrochloride of carbon. It has an aromatic odor, not unlike that of oil of caraways.

OLEIC ACID. The product resulting

from the action of alkalies upon the *elaine*, or liquid part of oils and fats.

OLEIN, is the thin oily part of fats naturally associated with glycerine, margarine, and stearine.

OLEON. A peculiar liquid obtained by the distillation of a mixture of oleic acid and lime.

OLIBANUM. A gum resin, imported from the Levant, in yellowish-white and nearly opaque drops or tears; it has a bitterish flavor, and has been used in medicine. When burned it exhales rather an agreeable odor. and is sometimes called *frankincense*. It is either the produce of the *Juniperus lycia*, or of the *Boswellia serrata*.

It is now only used as incense in Roman Catholic churches.

OLIVE. (Lat. olea.) A genus of trees belonging to the Diandria Monagynia class of plants. The *Olea Europæa* has an upright stem, with numerous branches, grows to the height of twenty or thirty feet, and differs from most trees in yielding a fixed oil from the pericarp instead of from the seed. The olive tree has in all ages been held in peculiar estimation; and some authors have styled it a "mine upon earth." It was sacred to Minerva. Olive wreaths were used by the Greeks and Romans to crown the brows of victors; and it is still universally regarded as emblematic of peace. The olive flourishes only in warm and comparatively dry parts of the world, as the south of France and Spain; in Italy, Syria, and the north of Africa; and though it has been raised in the open air in this country, its fruit did not ripen. The fruit is a smooth oval plum, about three quarters of an inch in length, and half an inch in diameter; of a deep violet color when ripe; whitish and fleshy within; bitter and nauseous, but replete with a bland oil. Olives intended for preservation are gathered before they are ripe. In pickling, the object is to remove and to preserve them green by impregnating them with a brine of aromatized sea-salt; and for this purpose various methods are employed. But it is chiefly for the sake of its oil that the olive tree is cultivated. Olive oil is pale yellow; its density is 9·10. When fresh, and of fine quality, it is almost tasteless, having only a very slight and agreeable nutty flavor. It is less apt than most other fixed oils to become viscid by exposure, and hence is preferred for greasing clock and watch-work. It is largely used as an article of food. It is the principal article of export from the kingdom of Naples.

Olive Oil. (See Oils Fat.)

OLIVINE. A variety of *Chrysolite* containing oxide of iron of an olive-green color, it is sometimes found associated with meteoric iron and in Basalt.

ONYX. A regularly banded agate, much prized for cameos, especially where the colors are very distinct and opposed. Any stone exhibiting layers of two or more colors strongly contrasted is called an onyx.

OOLITE. A granular variety of carbonate of lime, frequently calld *roestone*. The frequency of the occurrence of this particular form of limestone in a great series of deposits, lying between the subcretaceous formations and the new red sandstone, has caused English geologists to give the whole series the name of olitic. It is largely developed in England and France.

OPAL. A beautiful mineral characterized by its iridescent reflection of light: it is very brittle. It consists of silica, with about 10 per cent. of water. *Common opal* in some of its characters resembles the preceding; but it has no play of colors, and is abundant, the former being a very rare mineral. Opal is found in different parts of Europe, but particularly in Hungary; in the East Indies, &c.

OPALIZED WOOD. Wood petrified by silica and acquiring a structure resembling common opal.

OPIUM. The inspissated juice of the poppy, obtained by wounding the unripe seed capsules of the *Papaver somniferum*, collecting the milky juice which exudes and dries in the sun, and kneading it into cakes. The cakes of the best opium are covered externally with pieces of dried leaves and the seed capsules of some species of *Rumex*. It should be of a rich brown color, tough consistency, and smooth uniform texture; its peculiar narcotic smell should be strong and fresh; its taste bitter, warm, and somewhat acrid. The chemical analysis of opium has rendered it probable that its activity as a medicine depends upon the presence of a peculiar alkaline base called *morphia*, in combination with an acid which has been termed *meconic acid*. Opium also contains *narcotine*, *narceine*, *codein*, gum resin, extractive matter, and small portions of other proximate principles.

The chief countries in which opium is prepared are India, Egypt, Turkey, and other parts of Asia; it is even cultivated in Italy, France, and England, but the climate of Europe seems to be too uncertain to allow of its regular production. Opium is pretty extensively used, both as a masticatory and in smoking, in Turkey and India; but its great consumption is in China and the surrounding countries, where the habit of smoking it has become all but universal. The supplies for the Chinese market are derived from India and Turkey, but chiefly from the former. Indian opium is distinguished into three kinds: the Patna or that grown in the province of Bahar, the Benares, and the Malwa; of which the first is in the highest repute. The cultivation of opium in India is a strict government monopoly. Every one who chooses may, within the prescribed regulations, engage in the opium cultivation; but the drug, when prepared, must all be sold to the government at a fixed price, which is said to be so far from remunerating the growers that, were it not for the advances which government are obliged to make to enable them to carry on the business, the cultivation of opium would be discontinued in the greater portion of India. This monopoly has sometimes yielded a nett revenue of £1,000,000 a year. This revenue has, however, of late years materially decreased, owing to the introduction into China of large supplies of opium from Turkey, into which it is found impossible to extend the monopoly. The East India opium is exported in chests of 159¼ lbs. each. The introduction of opium into China was a legitimate branch of traffic down to the close of the last century. Ever since that period, however, the trade has been contraband; but though the Chinese government has issued edict upon edict prohibiting the importation of the drug, the consumption of Indian opium in China has, in little more than forty years, risen from 1,000 to about 27,000 chests per annum. Such an extraordinary increase in a trade prohibited by law is attributable only to the corruption of the Chinese authorities. At first the trade was carried on at Whampoa, 15 miles below Canton; and next at Macao, whence it was driven by the exactions of the Portuguese; and the principal entrepôt was, till the recent outbreak of hostilities between the British and Chinese, in the bay of Lintin. The opium is kept on board ships, commonly called receiving ships, of which there are often ten or twelve lying together at anchor. The sales are mostly effected by the English and American agents in Canton, who give orders for the delivery of the opium; which, on the order being produced, is handed over to the Chinese smuggler, who comes alongside at night to receive it. Frequently, however, the smuggler purchases the opium on his own account, paying for it on the spot in silver, it being a rule of the trade never violated that the money must be paid before the opium is delivered. When the drug is landed, the laws are equally set at defiance in its progress through the country, smoking houses being, it is said, everywhere established. During the first ten years of the present century, the exports from India to China were about 2,500 chests. In 1821-1822, after the introduction of Malwa opium into the markets of Bombay and Calcutta, the exports increased to 4,628 chests; and owing no doubt to the greatly increased supply and lower price of the article, the exports in 1831-1832 exceeded 20,000 chests, worth more than 13,000,000 dollars; and in 1837-1838 exceeded 30,000 chests, worth 20,000,000 dollars.

In 1839, the Chinese government endeavored to stop the importation of this pernicious drug into that country, which led to open hostilities and defeat on the part of the Chinese who were obliged to pay heavily for the expenses of the war. To raise this, an extra duty was levied on tea exported, which the English almost wholly paid, thus bearing the full expenses of the war. The nefarious and successful attempt of England to force an unwilling trade on China reflects indelible disgrace upon that kingdom.

Opian or narcotine, and morphia, may be well prepared by the following process. The watery infusion of opium being evaporated to the consistence of an extract, every 3 parts are to be diluted with one and a half parts in bulk of water, and then mixed in a retort with 20 parts of ether. As soon as 5 parts of the ether have been distilled over, the narcotic salt contained in the extract will be dissolved. The fluid contents of the retort are to be poured hot into a vessel apart, and the residuum being washed with 5 other parts of ether, they are to be added to the former. Crystals of narcotine will be obtained as the solution cools. The remaining extract is to be diluted in the retort with a little water, and the mixture set aside in a cool place. After some time, some narcotine will be found crystallized at the bottom. The supernatant liquid thus freed from narcotine being decanted off, is to be treated with caustic ammonia; and the precipitate thrown upon a filter. This, when well washed and dried, is to be boiled with a quantity of spirit of wine at 0·84, equal to thrice the weight of the opium employed, containing 6 parts of animal charcoal for every hundred parts of the drug. The alcoholic solution being filtered hot, affords, on cooling, colorless crystals of morphia.

This alkali may be obtained by a more direct process without alcohol or ether. A solution of opium in vinegar, is to be precipitated by ammonia; the washed precipitate is to be dissolved in dilute muriatic acid, the solution is to be boiled along with powdered bone black, filtered, and then precipitated by ammonia. This, when washed upon a filter and dried, is white morphia, which may be dissolved in hot alcohol, if fine crystals be wanted. (See MORPHIA.)

OPSIOMETER. An instrument for measuring the extent of the limits of distinct vision in different individuals, and consequently for determining the focal length of lenses necessary to correct imperfections of the eye. A contrivance for this purpose, by M. Lehot, is described in the Notes by M. Quetelet to the French translation of *Herschel's Treatise on Light.* Its principle depends on the appearance presented by a straight line placed very near the eye, in the direction of its axis; and the principle is carried into practice by placing a thread of white silk on a narrow rule covered with black velvet, and furnished with a suitable apparatus for marking the exact points at which the thread begins and ceases to be distinctly seen, when held in a certain position with respect to the eye. An instrument for the same purpose, on a different principle, had formerly been suggested by Dr. Young.

ORCIN. A crystallizable coloring matter obtained from the lechen, *Variolaria Orcina.*

ORES. (Germ. erze.) The mineral bodies from which metals are extracted. Metals exist in the ores in one or the other of the four following states: 1. In a metallic state, and either solitary or combined with each other; in the latter case forming alloys. 2. Combined with sulphur, forming sulphurets. 3. Combined with oxygen, forming oxides. 4. Combined with acids, forming carbonates, phosphates, &c., which generally go by the name of metallic salts.

Ores are very numerous. There are of

Antimony	14 *Ores.*
Arsenic	10
Bismuth	5
Cobalt	12
Copper	31

And so for others.

Certain ores which contain the metals most indispensable to human necessities have been treasured up by the Creator in very bountiful deposits, constituting either great masses in rocks of different kinds, or distributed in lodes, veins, nests, concretions, or beds with stony and earthy admixtures; the whole of which become the objects of mineral exploration. These precious stores occur in different stages of the geological formations; but their main portion, after having existed abundantly in the several orders of the primary strata, suddenly cease to be found towards the middle of the secondary. Iron ores are the only ones which continue among the more modern deposits, even so high as the beds immediately beneath the chalk, when they also disappear, or exist merely as coloring matters of the tertiary earthy beds.

The strata of gneiss and mica-slate constitute in Europe the grand metallic domain. There is hardly any kind of ore which does not occur there in sufficient abundance to become the object of mining operations, and many are found nowhere else. The transition rocks, and the lower part of the secondary ones, are not so rich, neither do they contain the same variety of ores. But this order of things, which is presented by Great Britain, Germany, France, Sweden, and Norway, is far from forming a general law; since in equinoctial America the gneiss is but little metalliferous; while the superior strata, such as the clay-schists, the sienitic porphyries, the limestones, which complete the transition series, as also several secondary deposits, include the greater portion of the immense mineral wealth of that region of the globe.

All the substances of which the ordinary metals form the basis, are not equally abundant in nature; a great proportion of the numerous mineral species which figure in our classifications are mere varieties scattered up and down in the cavities of the great masses or lodes. The workable ores are few in number, being mostly sulphurets, some oxides, and carbonates. These occasionally form of themselves very large masses, but more frequently they are blended with lumps of quartz, felspar, and carbonate of lime, which form the main body of the deposit; as happens always in proper lodes. The ores in that case are arranged in layers parallel to the strata of the formation, or in veins which traverse the rock in all directions, or in nests or concretions stationed irregularly, or finally disseminated in hardly visible particles. These deposits sometimes contain apparently only one species of ore, sometimes several, which must be mined together, as they seem to be of contemporaneous formation; whilst, in other cases, they are separable, having been probably formed at different epochs. Under the particular metals will be found an account of the localities of ores, &c.; but the following general observations may prove useful in presenting a condensed resume of the whole subject.

1. *Tin* exists principally in primitive rocks, appearing either in interlaced masses in beds, or as a constituent part of the rock itself, and more rarely in distinct veins. Tin ore is found, indeed, sometimes in alluvial land, filling up low situations between lofty mountains.

2. *Gold* occurs either in beds or in veins, frequently in primitive rocks; though it is also found in other formations, and particularly in alluvial earth. When this metal exists in the bosom of primitive rocks, it is particularly in schists; it is not found in serpentine, but it is met with in greywacke in Transylvania. The gold of alluvial districts, called gold of washing or transport, occurs, as well as alluvial tin, among the debris of the more ancient rocks.

3. *Silver* is found, particularly in veins and beds, in primitive and transition formations; though some veins of this metal occur in secondary strata. The rocks richest in it are gneiss, mica-slate, clay-slate, greywacke, and old alpine limestone. Localities of silver-ore itself are not numerous, among secondary formations; but it occurs in combination with the ores of copper or of lead.

4. *Copper* exists in the three mineral epochas: 1. In primitive rocks, principally in the state of pyritous copper, in beds, in masses, or in veins; 2. In transition districts, sometimes in masses, sometimes in veins of copper pyrites; 3. In secondary strata, especially in beds of cupreous schist.

5. *Lead* occurs also in each of the three mineral epochas; abounding particularly in primitive and transition grounds, where it usually constitutes veins, and occasionally beds of sulphuretted lead (galena.) The same ore is found in strata or in veins among secondary rocks, associated now and then with ochreous iron-oxide and calamine (carbonate of zinc;) and it is sometimes disseminated in grains through more recent strata.

6. *Iron* is met with in four different mineral eras, but in different ores. Among primitive rocks magnetic iron ore and specular iron ore occur chiefly in beds, sometimes of enormous size: the ores of red or brown oxide of iron (hæmatite) are found generally in veins, or occasionally in masses with sparry iron, both in primitive and transition rocks; as also sometimes in secondary strata; but more frequently in the coal-measure strata, as beds of clay-ironstone, of globular iron oxide, and carbonate of iron. In alluvial districts, we find ores of clay-ironstone, granular iron-ore, bog-ore, swamp-ore, and meadow-ore. The iron ores which belong to the primitive period have almost always the metallic aspect, with a richness amounting even to 80 per cent. of iron, while the ores in the posterior formations become, in general, more and more earthy, down to those in alluvial soils, some of which present the appearance of a common stone, and afford not more than 20 per cent. of metal, though its quality is often excellent.

7. *Mercury*, as a sulphuret, occurs principally among secondary strata in disseminated masses, along with combustible substances; though the metal is met with occasionally in primitive countries.

8. *Cobalt* belongs to the three mineral epochas; its most abundant deposits are veins in primitive rocks; small veins containing this metal are found, however, in secondary strata.

9. *Antimony* occurs in veins or beds among primitive and transition rocks.

10. *Bismuth* and *nickel* do not appear to constitute the predominating substance of any mineral deposits; but they often accompany cobalt.

11. *Zinc* occurs in the three several formations; namely, as sulphuret, or blende, particularly in primitive and transition rocks; as calamine, in secondary strata, usually along with oxide of iron, and sometimes with sulphuret of lead.

In the analysis of ores, it is impossible to lay down any general rule, so numerous are the ores themselves, and so diversified the means necessary to be adopted in the various analytic processes. Under each particular metal will be found an account of its most important ores, and we shall here restrict ourselves to a few general remarks on the theory of smelting ores.

It is probable that the coaly matter employed in that process is not the *immediate* agent of their reduction: but the charcoal seems first of all to be transformed by the atmospherical oxygen into the oxide of carbon, which gaseous product then surrounds and penetrates the interior substance of the oxides, with the effect of decomposing them, and carrying off their oxygen. That this is the true mode of action, is evident from the well-known facts that bars of iron, stratified with pounded charcoal, in the steel-cementation chest, most readily absorb the carbonaceous principle to their innermost centre, while their surfaces get blistered by the expansion of carburetted gases formed within; and that an intermixture of ores and charcoal is not always necessary to reduction, but merely an interstratification of the two, without intimate contact of the particles. In this case, the carbonic acid which is generated at the lower surfaces of contact of the strata, rising up through the first bed of ignited charcoal, becomes converted into carbonic oxide; and this gaseous matter, passing up through the next layer of ore, seizes its oxygen, reduces it to metal, and is itself thereby transformed once more into carbonic acid; and so on in continual alternation. It may be laid down, however, as a general rule, that the reduction is the more rapid and complete the more intimate the mixture of the charcoal and the metallic oxide has been, because the formation of both the carbonic acid and carbonic oxide becomes thereby more easy and direct. Indeed the cementation of iron bars into steel will not succeed, unless the charcoal be so porous as to contain, interspersed, enough of air to favor the commencement of its conversion into the gaseous oxide; thus acting like a ferment in brewing. Hence, also, finely pulverized charcoal does not answer well, unless a quantity of ground iron cinder or oxide of manganese be blended with it, to afford enough of oxygen to begin the generation of carbonic oxide gas; whereby the successive transformations into acid and oxide are put in train.

Iron is the most abundant of ores our country affords. Its value is ten times that of gold and silver, and one half the value of all the metals produced in the United States. Iron is found in every State of the Union.

The most valuable mine is one in Salisbury, Ct., which yields 3,000 tons annually. The mines in Duchess and Columbia counties, in the State of New-York, produce 20,000 tons of ore; Essex county, 1,500 tons; Clinton, 8,000; Franklin, 600; St. Lawrence, 2,000; amounting in all to more than $500,000. The value of the iron produced in the United States, in 1835, was $5,000,000; in 1837, $7,700,000.

In Ohio, 1,200 square miles are underlaid with iron. A region explored in 1838 would furnish iron sixty-one miles long, and six miles wide; a square would yield 8,000,000 tons of pig-iron; so that this district would contain 1,000,000,000 tons. By taking from this region 400,000 tons annually, (a larger quantity than England produced previous to 1829,) it would last 2,700 years—as long a distance, certainly, as any man looks ahead! In the States of Kentucky and Tennessee, 100,000 tons are annually manufactured.

The most extensive lead mines in the world are in Missouri, where the lead region is seventy miles long by fifty wide. These mines in 1826, produced 7,500,000 tons, and the whole produce of the United States was 8,322,105.

The quantity of lead manufactured in the United States, in 1828, was 12,311,730 lbs.; in 1829, 14,541,810 lbs.; in 1838, 8,332,105; and in 1842, 4,281,687.

The copper trade, until within a year or two, has not been of much importance, as the results of the efforts made were not such as to justify any great operations. But now it appears to be attracting a good deal of attention. Whether the demand of the copper stock is a fair index to the value of the copper regions remains to be seen.

ORPIMENT occurs in indistinct crystalline particles, and sometimes in oblique rhomboidal prisms; but for the most part, in kidney and other imitative forms; it has a scaly and granular aspect; texture foliated, or radiated; fracture small granular, passing into conchoidal; splintery, opaque, shining, with a weak diamond lustre; lemon, orange, or honey yellow; sometimes green; specific gravity. 3·44 to 3·6. It is found in floetz rocks, in marl, clay, sandstone, along with realgar, lead-glance, pyrites, and blende, in many parts of the world. It volatilizes at the blowpipe. It is used as a pigment, and is a yellow sulphuret of arsenic.

The finest specimens come from Persia, in brilliant yellow masses, of a lamellar texture, called golden orpiment.

Artificial orpiment is manufactured chiefly in Saxony, by subliming in cast-iron cucurbits, surmounted by conical cast-iron capitals, a mixture in due proportions of sulphur and arsenious acid (white arsenic). As thus obtained, it is in yellow compact opaque masses, of a glassy aspect; affording a powder of a pale yellow color. Genuine orpiment is often adulterated with an ill-made compound; which is sold in England by the preposterous name of king's yellow. This fictitious substance is frequently nothing else than white arsenic combined with a little sulphur; and is quite soluble in water. It is therefore a deadly poison.

The first kinds of native orpiment are reserved for artists; the inferior are used for the indigo vat. They are all soluble in alkaline leys, and in water of ammonia.

ORRIS ROOT. The root of the *Iris Florentina*. It has an agreeable odor, much like violets, and is sometimes used in perfumed powders; it is also turned into little balls for issues, called *orris peas*.

ORTHITE. A mineral which occurs in straight rays or layers in Scandinavian granite. It contains cerium and yttria.

OSCILLATION. In mechanics, the vibration or alternate ascent and descent of a pendulous body. The centre of oscillation is a point in the oscillating body, such that if all the matter of the body were there collected, the oscillations would be performed in the same time. The axis of oscillation is a straight line passing through the point of suspension parallel to the horizon, or perpendicular to the plane in which the oscillation is made. Oscillations in small arcs of a circle, or in cycloidal arcs of any length, are isochronal or performed in equal times.

OSMAZOME. The extractive matter of muscular fibre, which gives the peculiar smell to boiled meat, and flavor to broth and soup.

OSMIUM. A metallic substance found associated with the ore of platinum; its peroxide is extremely volatile, and has a peculiar pungent odor, which suggested the name of the metal: from *οσμη odor*. Neither osmium nor its compounds have been applied to any use, and it is a rare substance.

OTTAR, or OTTAR OF ROSES. The volatile or odorous oil of the rose: it is of a soft, buttery consistence, and deposits, when fluid, a crystallizable portion, which is sparingly soluble in alcohol: it is much used as a perfume. The finest ottar of roses is prepared at Ghazedpore in India.

OXALATES. Salts of the oxalic acid.

OXALIC ACID. A vegetable acid, first discovered in the juice of the *Oxalis acetosella*; it was afterwards ascertained that the same acid might be produced artificially by the action of the nitric acid upon sugar; this process yields it in slender prismatic crystals, intensely sour, and soluble in about ten parts of cold water. These crystals consist of 1 atom of real acid, and 3 of water: the equivalent of the acid is 36; and in its anhydrous state, as it exists in the dry oxalates, it is constituted of 2 atoms of carbon (6×2) =12, and 3 of oxygen (8×3)=24: so that it may be represented by an atom of carbonic acid and one of carbonic oxide. Solutions of oxalic acid, or of soluble oxalates, yield an insoluble precipitate in solutions containing lime and its salts: hence its use in the laboratory as a test of the presence of that earth. The solution of oxalate of ammonia is generally used for the purpose. Oxalic acid is a powerful poison, and, from its resemblance to Epsom salt, it has sometimes been sold and mistaken for that harmless aperient. In such cases, the best antidote is a mixture of chalk and water, and where it is immediately administered it generally prevents the accession of fatal symptoms: it forms an insoluble oxalate of lime, which is inert.

It is usually prepared upon the small scale by digesting four parts of nitric acid of specific gravity 1·4, upon one part of sugar in a glass retort; but on the large scale, in a series of salt-glazed stoneware pipkins, two thirds filled, and set in a water bath. The addition of a little sulphuric acid has been found to increase the product. 15 pounds of sugar yield fully 17 pounds of the crystalline acid. This acid exists in the juice of wood sorrel, the *oxalis acetosella*, in the state of a bioxalate; from which the salt is extracted as an object of commerce in Switzerland, and sold under the name of salt of sorrel, or sometimes, most incorrectly, under that of salt of lemons.

Some prefer to make oxalic acid by acting upon 4 parts of sugar, with 24 parts of nitric acid of specific gravity 1·220, heating the solution in a retort till the acid begins to decompose, and keeping it at this temperature as long as nitrous gas is disengaged. The sugar loses a portion of its carbon, which, combining with the oxygen of the nitric acid, becomes carbonic acid, and escapes along with the deutoxide of nitrogen. The remaining carbon and hydrogen of the sugar being oxidized at the expense of the nitric acid, generate a mixture of two acids, the oxalic and the malic. Whenever gas ceases to issue, the retort must be removed from the source of heat, and set aside to cool; the oxalic acid crystallizes, but the malic remains dissolved. After draining these crystals upon a filter funnel, if the brownish liquid be further evaporated, it will furnish another crop of them. The residuary mother water is generally regarded as malic acid, but it also contains both oxalic and nitric acids; and if heated with 6 parts of the latter acid, it will yield a good deal more oxalic acid at the expense of the malic. The brown crystals now formed being, however, penetrated with nitric, as well as malic acid, must be allowed to dry and effloresce in warm dry air, whereby the nitric acid will be got rid of without injury to the oxalic. A second crystallization and efflorescence will entirely dissipate the remainder of the nitric acid, so as to afford pure oxalic acid at the third crystallization. Sugar affords, with nitric acid, a purer oxalic acid, but in smaller quantity, than sawdust, glue, silk, hairs, and several other animal and vegetable substances.

Oxalic acid occurs in aggregated prisms when it crystallizes rapidly, but in tables of 4 and 6 sides when crystallized more slowly.

OXIDE. Compounds containing oxygen, but which are not *acid*, have been termed *oxides*. The metallic oxides are a most important class of bodies. To designate the different oxides of one base we generally use the first syllable of the Greek ordinal numerals, designating the first, second, third, &c., oxides by the terms *protoxide*, *deutoxide*, *tritoxide*, &c.; and when the base is saturated with oxygen, (still not acid) it is termed a *peroxide*. Compounds of bases with one atom and a half oxygen, or of two base and three oxygen, are now generally distinguished by the term *sesquioxides*. Deutoxides and tritoxides are commonly called *binoxides* and *teroxides*.

OXYGEN. This important element was discovered in 1774, by Dr. Priestly. It has been termed *dephlogisticated air*, *vital air*, and *empyreal air*. As it forms a component part of many of the acids, it was termed, at the framing of the new nomenclature, *oxygen gas*. There are several compounds of oxygen, which, when exposed to heat, are decomposed, and yield the gas in a state of purity: of these the best is chlorate of potash; but as that salt is expensive, we generally resort to black oxide of manganese, which, at a dull-red heat, gives out a considerable quantity of tolerably pure oxygen gas. Oxide of manganese, or bichromate of potass, heated with sulphuric acid, gives out oxygen.

Oxygen gas is colorless, tasteless, and inodorous; it is electro-negative, and therefore, when compounds containing it are electrically decomposed, it always appears at the positive surface. It is a little heavier than atmospheric air, in the proportion, that is, of 11 to 10; 100 cubical inches weighing 34·6 grains. It is not absorbed by water, and is neither acid nor alkaline. It has a powerful attraction for most of the simple substances, especially for the electro-positive bodies: the act of combining with it is called *oxidation*. The compounds thus formed are divided into *acids* and *oxides*: among the latter are the alkalies, and almost all salifiable bases. Oxidation is often attended with the evolution of heat and light, as in all processes of combustion in atmospheric air: sometimes it is slow, and unattended with such phenomena, as in the gradual rusting of metals. Oxygen is a most powerful supporter of combustion; it constitutes one fifth of the bulk of the atmosphere, and is the principle which enables combustible bodies to burn in it. The product of combustion, that is, the oxide or acid, is sometimes itself gaseous, as when charcoal, by burning, is converted into carbonic acid; or it is liquid, as hydrogen, by combustion, produces water; or it is solid, as when iron, by burning, produces oxide of iron. Oxygen gas is also essential to respiration; that is, to the evolution of carbonic acid from the blood.

OXIDATION OF METALS is effected either by the air and heat, by burning with nitrate of potash, by water, by acidulous solution, the excess of acid being subsequently withdrawn by an alkali, or other substance of greater affinity.

Oxidation renders metals susceptible of the action of acids, and hence their variety of salts. If the metal becomes a salt, it was previously an oxide, or was oxidized in the process.

To oxidize metals, after they are melted they are exposed in the furnace in a flat dish, and stirred. Zinc and mercury vaporize and require one to be exposed to air previously, and the other in a long-necked vessel, that it may not wholly escape, and yet rise to contact with air.

After metals are melted and burned they form oxides, 8 of which are white; iron, lead, copper, manganese, and mercury, which are red, or black, or yellow. Silver, too, is olive, and antimony yellow. Further heat converts these powders into glass, and they are generally soluble in acids or alkalies. Heated with charcoal, carburet of iron, oil, &c., they may be restored to the metallic form.

Iron combines with 28·75 and 48·12 of oxygen in 100, to form its black and red oxide.

Zinc with 24·24.

Arsenic with 34·93 and 52·4.

Manganese with 28·75 and 57·5.

Bismuth with 11·28.

Antimony 18·6.

Copper 12·5 for red, and 2·5 for black.

Silver 7·272.

Mercury 4 for black, and 8 for red.

Lead 11·58 for red, and 15·384 for brown.

The alkaline metals absorb still more: magnesium 66·6, sodium, 33·3, calcium 38·39, potassium 20, and barium 11·42 all white.

Gold affords 2 chemical oxides, and its leaves are changed to purple color by electricity.

PACKING *for Stuffing Boxes.* Mr. W. H. Shock, assistant-engineeer, U. S. N., Philadelphia, has invented an improvement in soft metal packing, which appears to be a good one, and for which he has taken measures to secure a patent. It is designed for the stuffing-box of a steam cylinder around the piston-rod, and consists of sectional conical cups of soft metal fitted into corresponding cups in brass or iron rings, acted on by the piston-rod and a hellicle spring, so as to be elastic, and from the peculiar shape of the soft metal packing and the action of the spring, the packing is always kept close up or binding on the piston-rod, however much it may be out of line.

PACKFONG. The Chinese name of the alloy of nickel and copper commonly called *German silver.* It is an alloy of 7 parts of zinc, 2·5 copper, and 6·5 nickel.

PACOS. The Peruvian name of an earthy-looking ore, which consists of brown oxide of iron, with imperceptible particles of native silver disseminated through it.

PADDING, in calico-printing, is the impregnation of the cloth with a mordant.

PADDLE. A kind of oar used by savage nations in navigating their canoes. The paddle is broader at the end than the common oar; and being employed at the stern of the canoe, not only impels her forwards, but regulates her course exactly like a rudder.

PADDLE-WHEELS are the rotating levers with which steam or other power acts against water, in propelling a vessel. The idea is not new, for rotating paddles were turned by oxen, &c., in the Middle Ages. Many patent improvements and varieties of form have been proposed; the chief object is to keep them vertical to the water, and this has been effected by an extra arm, worked by cramps, in connection with the pivot of the float-boards, which turn on the arms.

It has been proposed to work paddles by sails, in certain cases, especially when any accident befalls the boiler or works of the engine.

Woodcraft proposes to make paddles of spiral vanes, with increasing angles of inclination with the axis and increasing distance, and has taken out a patent for the idea.

PAINT, *Use of.* It is not an uncommon thing for some paints, especially when exposed to the atmosphere, to rub off like whitewash, after they have been put on for about six or eight months. We have known white paint do this, although both the oil and white lead were said to be good. In respect to white paint, which is most extensively used, there are three things which may be the causes of its inferiority and rubbing off. These are bad oil, bad lead, and too much turpentine. The best linseed oil only should be used, and it should be boiled, but not too long nor at too great a heat. Linseed oil is frequently adulterated with sun-flower oil, which is very inferior to that of linseed.

Sometimes white lead is sold which is very inferior to others, but painters know how to judge between the good and bad. The best can easily be ascertained by painters from the quantity of oil required to give it proper consistency. In mixing paints, there should be no turpentine at all used for outside work (at most the smallest possible quantity), because the turpentine makes a soap of the oil, consequently, it soon will rub off or be washed away by storms, &c. The only benefit of boiling linseed oil is to drive away its moisture, and ammonia, so that the gluten of the oil will form a beautiful skin or varnish, when dry, to protect the lead from the effects of the atmosphere. While turpentine forms a good varnish with resins and gums, its combination with oil is altogether different, forming a soap; hence those who know not this fact, and use too much turpentine with their paints for outside work, may expect to see it disappear before it is very old. The best way to put on white lead for outside work, is to commence with a very thin coat, and let it dry perfectly. It is better to put on four thin coats, one after another, than two thick ones. The labor, to be sure, is more expensive, but those who buy their own paint, and use it in the country, will find out that it will be a saving in the end.

In painting woodwork, the first operation consists in killing the knots, from which the turpentine would otherwise exude and spoil the work. To effect this, the knots are covered with fresh slaked lime, which dries up and burns out the turpentine. When this has been on twenty-four hours, it is scraped off, and the knots painted over with a mixture of red and white lead, mixed with glue size. After this they are gone over a second time with red and white lead, mixed with linseed oil. When dry they must be rubbed perfectly smooth with pumice stone, and the work is ready to receive the priming coat. This is composed of red and white lead, well diluted with linseed oil. The nail holes and other imperfections are then stopped with putty, and the succeeding coats are laid on, the work being rubbed down between each coat, to bring it to an even surface. The first coat after the priming is mixed with linseed oil and a little turpentine. In laying on the second coat, where the work is not to be finished white, an approach must be made to the required color. The third coat is usually the last, and is made with a base of white lead, mixed with the requisite color, and diluted with one third of linseed oil to two thirds of turpentine, for inside.

Painting on stucco, and all other work in which the surface is required to be without gloss, has an additional coat mixed with turpentine only, which, from its drying of one uniform *flat* tint, is called a flatting coat.

If the knots show through the second coat, they must be carefully covered with silver leaf.

Work finished as above described would be technically specified as knotted, primed, painted 3 oils, and flatted.

Flatting is almost indispensable in all delicate interior work, but it is not suited to outside work, as it will not bear exposure to the weather.

Painting on stucco is primed with boiled linseed oil, and should then receive at least three coats of white lead and oil, and be finished with a flat tint. The great secret of success in painting stucco is, that the surface should be perfectly dry; and, as this can hardly be the case in less than two years after the erection of a building, it will always be advisable to finish new work in distemper, which can be washed off whenever the walls are sufficiently dry to receive the permanent decorations.

PAINT, New White. Two varieties of white are now in the market as a substitute for lead. One is the white oxide or the sesquioxide of antimony, which was lately brought into notice in France, and has been much used in England. It does not darken by exposure to air or sulphuretted vapors, and has a good body: it is also cheaper than white lead. The other variety has been brought into notice here by the New Jersey Zinc Manufacturing Company, who have prepared the flowers or white oxide of zinc for that purpose. It is a cheap and harmless paint, does not alter or blacken like lead, but it does not appear in itself to have sufficient body to recommend its extensive use.

PAINTING HOUSEWORK is effected for the most part by priming, and then applying two or three coats of white lead or ceruse, in linseed oil. Colors are added at pleasure, of lamp-black, red lead or ochres, or pigments.

Priming, used by painters for new woodwork, is a thin solution of white and red lead in linseed oil.

Flexible Paint. (For Canvas.) In a hot soap ley, of water 6 lbs., and soap 1 lb., stir well 112 lbs. of oil paint, and use while warm.

Relief. London painters produce striking relief in inscriptions. The main surface is gold, as a middle tint. The strong light of yellow ochre and white is placed at the side, and the upper and under part is in warm shade. A very strong shadow is seen under this, upon the rosewood, which makes the warm shade appear as a reflected light, and a fainter shadow is put in beyond this. The effect is so masterly, that it is difficult to tell whether the letters are raised or not.

White Paint. Skim milk 2 qts.; fresh slaked lime 8 oz.; linseed oil 6 oz.; white Burgundy pitch 2 oz.; Spanish white 3 lbs. The lime must be slaked in water, exposed to the air, mixed in about one fourth of the milk; the oil in which the pitch is previously dissolved must be added gradually, then the rest of the milk, and afterwards the Spanish white. This quantity is sufficient for 27 square yards, two coats, and the expense not more than 10d.

Spanish White is made by grinding fine chalk with 1-10th of alum in water, shaking and drying in the air and then in fire.

Cheap Paint. Gas-tar mixed with yellow ochre makes an excellent green paint, well adapted for preserving coarse wood-work and iron rails.

PAINTING ON GLASS is effected chiefly by colors derived from metals. The colors are laid on by fluxes, as soft glass, and easily vitrified bodies. The colors are fixed by annealing the metals to the glass. The glass used is crown-glass. The annealing is performed in a kiln built for the purpose. The fluxes are minium, calcined borax, salt, and powdered flint-glass. Gold produces the splendid ruby color. Silver, a yellow. Copper, a red. Tin, a white. Iron, a carnation. Ultra-marine, blue. Cobalt, blue. Smalt, light blue. Antimony, yellow and red. Manganese, black. Umber, for browns. The flux in this art is like the oil and varnish of our painting.

The best flux is composed of 16 flint-glass, 6 pearl-ash, 1 salt, and 1 borax. A soft flux is 8 flint-glass, 2 minium, 1 borax. They are vitrified together, and then powdered. Pearl-ash and borax soften, and flint-glass hardens.

An orange stain is produced by silver and antimony for yellow, and pure venetian, red. The two first are melted together, and when reduced to impalpable powder, are mixed with the red in water. This pigment is then laid on the glass in due form, with a brush, and left to dry. Then burnt-in, and it penetrates through the glass in a fine golden color. So with other metals, and other colors, some requiring fluxes. It is ably treated at length by Whittock, and being an art not generally practicable, enough has been said of it in this general work.

The fluxes are used in calcining black from scales of iron, jet, and manganese; carnation from red chalk and jet; scarlet from gold and tin, &c., &c.

PALLADIUM. A rare metal, possessed of valuable properties, was discovered in 1803, by Dr. Wollaston, in native platinum. It constitutes about 1 per cent. of the Columbian ore, and from ¼ to 1 per cent. of the Uralian ore of this metal; occurring nearly pure in loose grains, of a steel-gray color, passing into silver white, and of a specific gravity of from 11·8 to 12·14; also as an alloy with gold in Brazil, and combined with selenium in the Harz near Tilkerode. Into the nitro-muriatic solution of native platinum, if a solution of cyanide of mercury be poured, the pale yellow cyanide of palladium will be thrown down, which being ignited affords the metal. This is the ingenious process of Dr. Wollaston. The palladium present in the Brazilian gold ore may be readily separated as follows: melt the ore along with two or three parts of silver, granulate the alloy, and digest it with heat in nitric acid of specific gravity 1·3. The solution containing the silver and palladium, for the gold does not dissolve, being treated with common salt or muriatic acid, will part with all its silver in the form of a chloride. The supernatant liquor being concentrated and neutralized with ammonia, will yield a rose-colored salt in long silky crystals, the ammonia-muriate of palladium, which being washed in ice-cold water, and ignited, will afford 40 per cent. of metal.

Pure palladium resembles platinum, but has more of a silver hue; when planished by the hammer into a cup, such as that of M. Breant, in the Museum of the Mint at Paris, it is a splendid steel-white metal, not liable, like silver, to tarnish in the air. Another cup made by M. Breant, weighing 2 lbs. (1 kilogramme), was purchased by Charles X., and is now in the *garde-meuble* of the French crown. The specific gravity of this metal, when laminated, is stated by Dr. Wollaston at 11·8, and by Vauquelin at 12·1. It melts at from 150° to 160° Wedgewood; and does not oxidize at a white heat. When a drop of tincture of iodine is let fall upon the surface of this metal, and dissipated over a lamp flame, a black spot remains, which does not happen with platinum. A slip of palladium has been used with advantage to inlay the limbs of astronomical instruments, where the fine graduated lines are cut, because it is bright, and not liable to alteration, like silver.

There are a protoxide and peroxide of palladium. The proto-chloride consists of 60 of metal and 40 of chlorine; the cyanide of 67 of metal, and 83 of cyanogen.

PALLETS, in clock and watch work, are the pieces connected with the pendulum or balance which receive the immediate impulse of the swing-wheel, or balance-wheel. They are of various forms and constructions, according to the kind of escapement employed.

PALMS. Called by Linnæus, from their noble and stately appearance, the princes of the vegetable kingdom, are a natural order of Arborescent Endogens, chiefly inhabiting the tropics, distinguished by their fleshy, colorless, six-parted flowers, inclosed within spathes;

their minute embryo, lying in the midst of albumen, and remote from the hilum; and rigid, plaited or pinnated inarticulated leaves, sometimes called fronds. Wine, oil, flax, flour, sugar, and salt, says Humboldt, are the produce of this tribe; to which Von Martius adds thread, utensils, weapons, food, and habitations. The most common species is the cocoa-nut. Their wounded stems, or spathes, yield in abundance a saccharine fluid, known in India by the name of toddy. The succulent rind of the date is a most nutritious as well as agreeable fruit. Sago is yielded by the interior of the trunks of nearly all, except *Areca catechu*, the well known *pisang*, or betel-nut: the fruit of the latter species is remarkable for its narcotic or intoxicating power. The common canes or rattans of the shops are the flexible stems of species of the genus *Calamus*.

PALM OIL is obtained, in Guinea and Guyana, by expressing, as also by boiling, the fruit of the *avoira elais*. It has an orange color, a smell of violets, a bland taste, is lighter than water, melts at 84° Fahr., becomes rancid and pale by exposure to air, dissolves in boiling alcohol, and consists of 69 parts of oleine, and 31 of stearine, in 100. It is employed chiefly for making yellow soap. It may be bleached by the action of either chlorine or oxygen gas, as also by that of light and heat.

Besides the foregoing source, much of the palm oil of commerce is obtained from the *Cocos butyracea*, and is a concrete, white, unctuous, substance, rendered fluid and fragrant by gentle heat. As a substitute for tallow, it is the greatest domestic improvement of late years, and it is so abundant, both in Africa and Brazil, that it will, ere long, by cultivation, supersede tallow for candles and soap, and even coals, for gas-making.

The palm-tree, growing on the coast of Africa, furnishes, at the base or origin of its leaves, clusters of a yellow succulent fruit. Each of these bears some resemblance to a grape-shot. The bunches are of different sizes, and the fruit composing them of different shapes, as might be expected from their reciprocal pressure, although naturally round, when not exposed to it. The pulp of this fruit is soft, and of a bright yellow color—it is from this that the oil is obtained. Within it lies inclosed a hard and thick-shelled stone, of a dark color, within which is contained a firm white kernel, of a pleasant oily flavor. This kernel also affords an oil, which is not yellow, but white—and not fluid, but concrete even in Africa.

The yellow palm-oil, is quite fluid while in Africa, and that it is not until it has been exposed to the cold of our temperate regions that it becomes solid—whereas the oil of the kernel is always concrete, or nearly so. Both the white and the yellow oil are obtained by expression. The latter is procured in immense quantities in Africa, where it is partly consumed by the negroes along with their rice and pepper, or fried with their fish; and partly exported to Europe, where its principal use is in the manufacture of soap and candles.

PAPER. A thin and flexible substance of various colors, but most commonly white, used for writing and printing on, and for various other purposes. It is manufactured of vegetable matter, reduced to a pulp by means of water and grinding; and is made up into *sheets*, quires, and reams, each quire consisting of twenty-four sheets, and each ream of twenty quires.

For the chief purposes to which paper is applied in modern times the ancients had recourse to a variety of materials: stone, tablets of wood, plates of lead, skins, parchment, linen, layers of wax, tablets of ivory, and, above all, the papyrus. The ability to write, created a necessity for some material on which to incribe; and all these various materials were resorted to in succession, as the ineligibility of each induced a fresh endeavor to discover some more desirable substitute.

The papyrus was the immediate precursor of paper, and the article from which it was first manufactured. Egypt has the honor of the invention; and Isidore even fixes the locality at Memphis; the date remains in some obscurity, although it has been warmly disputed. Varro the Roman, ascribes it to the time of Alexander the Great, after the founding of Alexandria; but we find in Pliny the recital of a passage, extracted from the writings of Cassius Hemina, an ancient annalist, in which he speaks of some books, found in the tomb of Numa when it was opened, 535 years after his decease, and asserts that these books were of *paper*, and had been interred with him. As Numa preceded Alexander 300 years, this circumstance, if admitted, would carry back the date of the invention anterior to that time. However, the antiquity of such a date is much doubted; but as Pliny gives an account of the manner of making the papyrus paper, and it seems to have been in high reputation in the time of Alexander the Great, it is probable that such improvements were made during his reign as to enhance the value and increase the manufacture.

The great improvement in paper was its manufacture from cotton. It is supposed that the Chinese and Persians were acquainted with this material for its production, and that the Arabians learned it from their conquest in Tartary. The ancient paper bears no marks of the wire through which the water is drained in modern paper-making; and it is therefore inferred that a different process was employed. Paper made from cotton was in use earlier with the Greeks than with the Romans. The manufacture of paper from cotton cannot be traced farther back than to the tenth century; and the oldest manuscript document written on this cotton paper is dated 1050.

When or by whom linen paper was invented seems uncertain: the Chinese appear to have the best pretensions. Its introduction into England took place about the year 1342, in the reign of Edward III., although some have supposed it as early as 1320. France had it in 1314, and Italy in 1367. The Germans possess a specimen bearing the date of 1308, although it has been surmised that this single instance may have been a mixture of linen with cotton.

In the Tower, there are a few letters upon cotton paper, yet parchment or vellum was generally used; and these are among the earliest examples of any continued correspondence upon the more commodious material, which in England was very rarely employed. It is highly probable that, in the south of France, the supply was received from the Moorish merchants or manufacturers of Spain.

Perhaps no other manufacture ever remained so long nearly stationary; though within the last fifty years such great and rapid improvements have been made in it, as to equal, if not to surpass, any other branch of manufacturing industry.

The application of paper to the purposes of writing and printing, and the fact of its being indispensable to the prosecution of the latter, render its manufacture of the highest utility and importance. But, even in a commercial point of view, its value is very considerable. France, Holland, and Genoa had, for a lengthened period, a decided superiority in this department. The finest and best paper being made of linen rags, its quality may be supposed to depend, in a considerable degree, on the sort of linen usually worn in the country where it is manufactured; and this circumstance is said to account for the greater whiteness of the Dutch and Belgian papers as compared with those of the French and Italians, and, still more, of the Germans. The rags used in the manufacture of writing-paper in Great Britain, are collected at home; but those used in the manufacture of the best printing-paper are imported principally from Italy, Hamburgh, and the Austrian States, by way of Trieste. The value of the rags saved in the United States is nearly 2½ million dollars yearly.

We believe, however, that it was owing rather to the want of skill, than, as has sometimes been supposed, to the inferior quality of the linen, that the manufacture of paper was not carried on with much success in England till a comparatively recent period. The manufacture is said to have been considerably improved by the French refugees who fled to England in 1685. In 1690, however, the manufacture of white paper was attempted; and, within a few years, most branches were much improved. In 1721, it is supposed that there were about 300,000 reams of paper annually produced in Great Britain, which was equal to about two-thirds of the whole consumption. In 1783, the value of the paper annually manufactured was estimated at £780,000. At present, besides making a sufficient quantity of most sorts of paper for our own use, we annually export about £100,000 worth of books.

In 1818, Dr. Colquhoun estimated the value of paper annually produced in Great Britain at £2,000,000; but Mr. Stevenson, an incomparably better authority upon such subjects, estimated it at only half this sum. From information obtained from those engaged in the trade, we incline to think that the total annual value of the paper manufacture in the United Kingdom, exclusive of the duty, may at present amount to about £1,200,000 or £1,300,000. There are about 700 paper-mills in England, and from 70 to 80 in Scotland. The number in Ireland is but inconsiderable. About 27,000 individuals are supposed to be directly engaged in the trade; and, besides the workmen employed in the mills, the paper manufacture creates a considerable demand for the labor of millwrights, machinists, smiths, carpenters, iron and brass-founders, wire-workers, woollen manufacturers, and others in the machinery and apparatus of the mills. Some parts of these are very powerful, and subject to severe strain; and other parts are complicated and delicate, and require continual renovation.

Most of the American printing-paper is of cotton, on account of the extensive use of that article; and hence it is soft, easily torn, and perishable. The paper manufacture has rapidly increased in this country. In 1829, the quantity made in this country amounted to from five to seven millions a-year, and employed ten to eleven thousand persons. Machinery is almost altogether employed, and the quality of the paper is improved. It becomes better by keeping, and is therefore difficult to obtain in this country, the interest of capital being too high. Much of the linen paper now made is from rags imported, of which there were, at the port of New York alone, during 1846, 1847, and 1848, the following quantities imported:—

1846,	Bales,	7,066
1847,	„	15,463
1848,	„	23,313

The exports of paper and stationery in the years 1847 and 1848 were, respectively, of the value of $88,731 and $78,307.

We pass on from this brief account of the history and statistics of paper to the mechanical process of its production; only remarking, that many articles have been resorted to in its manufacture—the tendrils of the vine, the stalks of the nettle, the thistle, and mallow; the bark of the willow, the hawthorn, the beech, the aspen, and the lime. Some patents have been obtained for making it of straw; and the bine of the hop, it is presumed, might furnish material for the supply of paper; but, leaving these inferior substitutes, we shall confine ourselves to the description of paper made from linen rags, that being the staple of the manufacture.

The rags are sold to the manufacturers according to their respective quality: fine, being wholly linen, and of the best quality, is used for the finest writing-paper, and so in their gradation down to the commonest, which is coarse, often canvass, and can only be made into an inferior printing-paper when it has been thoroughly bleached. In these inferior papers some cotton is mixed. There are also the strong, coarse bags in which the rags are packed, and the colored rags, only fit for the most common papers; though out of these the blue are usually sorted for the purpose of making blue paper. It is necessary that these rags should be dusted; and, to accomplish this, they are either placed in a cylinder, formed of wire net, turning on pivots at each end, and enclosed in a box which receives the dust as it falls through the net-work, or else their sorting takes place over a table frame covered with wire net, through which the dust falls into a box beneath, as the workwoman proceeds in her labours. The first of these modes, however, is a great preservation of the health of those employed in the work. The rags are then cut into pieces not exceeding three or four inches square, the parts that have seams being thrown into a separate heap, or the sewing-thread might make filaments in the paper. In this process the rags are scrupulously sorted according to their texture and degree of strength, not according to their color; for, were they not carefully arranged by this rule, the fine in texture would be reduced to a pulp long before the coarse, and be lost in the preparation; or, if preserved, when reduced to a pulp, would not be found of the same consistency as the coarser sorts, and the paper, when manufactured, would necessarily be clouded and inferior. It is for these reasons that this part of the process is important. When carefully sorted, and the different degrees of texture having, by a longer or shorter process, been reduced to a pulp of similar consistency, they may then be mixed together; but this cannot be previously done. While in this state the rags often appear so dirty and discolored as to preclude all hope, to an inexperienced eye, that they can ever assume the purity of that beautiful fabric so valuable to the artist and the scribe. This purification used formerly to be effected by water running through a receptacle filled with the rags, which in its passage eventually carried off their soil; but the present more expeditious process is that of boiling them, mixed up with lime, in a species of chest, so perforated as to allow the admission of steam; and by this means they are partially bleached. Bleaching takes an important place in the process. The superfluous moisture is squeezed from the rags, and they are placed in a sort of chamber or receiver, which is air-tight, and pipes are conducted into it from a retort, which convey chlorine, formed, by the application of heat, from manganese, common salt, and sulphuric acid. This part requires much care; for if carried beyond its due point, it proves most injurious to the durability of the fabric. The rags when taken from this chamber are strongly imbued with a most nauseous smell, and require profuse and frequent washings. After this process they are put into the beating engines, and pass through a sort of trituration, which reduces them to a coarse and imperfect pulp, which is called half stuff or first stuff, and this is again levigated until it assumes the appearance of cream.

The state and quality of this pulp is of the utmost importance to the final perfection of the paper. If, in the levigation, the fibre should have been so entirely destroyed as to reduce it to a jelly, the paper will inevitably prove liable to break, moulder away, and be rotten; and this must result whatever be the previous excellence of the material. A fibre is absolutely necessary to the production of a servicable paper. Mr. Murray, in a little work on the subject full of practical science, recommends that a small proportion of unbleached flax should be added to the half stuff—an expedient that would doubtless much increase the strength and durability of the manufacture. But, unfortunately, so far from means being taken to improve its consistency, others are resorted to, for the sake of an increased profit, which deteriorate almost to destruction: we mean the introduction of plaster of Paris, or other earthy substances, into the pulp; and this can never be done without ensuring brittleness and want of cohesion as the result. While the pulp is in this state, the size, made from sheep-skins and other animal substances, together with a solution of alum, is introduced, excepting only in the manufacture of writing paper, and then the sheets are most generally sized after their formation.

A patent was granted in 1847, in this country, for the mode of making the pulp from straw. The material of straw has long been used for this purpose, but the method of treatment is believed to be new, and is as follows:—The straw, or other vegetable fibrous material, is heated or boiled with milk of lime twelve hours, in a suitable boiler, and the lime and coloring matter washed out in a suitable tub. The fibrous matter is then transferred to mill-stones, so arranged as to crush it, and at the end of this operation the pulpy matter is again transferred to another tub for further washing out the coloring matter. The pulpy matter is next removed to a second set of boilers, where fresh lime-water and an alkaline solution of the strength of two to four degrees of the hydrometer is supplied, and the heat continued for six hours.

At the end of this time, the whole liquor and pulp are forced up by steam pressure into a third washing tub, where it is washed, and sulphuric or muriatic acid of the ordinary strength used for bleaching purposes, is supplied, and the contents kept in agitation for two hours, and the acid is then entirely washed out. The pulp is next returned to the second set of boilers, where it is mixed with alkali of the strength of two to four degrees of the hydrometer, and boiled four hours, or until the alkali is spent.

The pulp and liquor are again forced up into the third washing tub, and all soluble matters washed out of it. Chloride of lime of the ordinary bleaching strength is now added, and agitation kept up for two hours longer; when steam is let on and the boiling continued until the salt is spent, when the whole is discharged into the fourth tub, where the spent chloride of lime is washed out. The pulp is now subjected to the operation of *souring*, which consists of submitting it to the action of acid and water of the usual strength used for bleaching, and keeping the whole in agitation for four hours. It is now ready to be discharged into a fifth tub or set of tubs, when the process is considered as completed.

The fine pulp, or stuff, as it is technically called, is transferred into a chest or large tub with a revolving agitator; from thence into a vat, usually about 5 feet in diameter, and 2½ feet in depth, and sustained at a proper temperature by means of a fire; and it is generally arranged for this vat to be placed against a wall of the room, that the fuel to the fire may be supplied at an aperture externally, to prevent any injury from smoke. During the whole of the subsequent process it is requisite that the pulp in the vat should be stirred up at short intervals, to keep it of an equal consistency. There are three workmen employed in this stage of the operation, called the *dipper*, the *coucher*, and the *lifter*. The dipper is provided with a mould, formed of well-seasoned mahogany, across which parallel wires are stretched close together, a few other stronger ones being also placed at right angles with them, and at some distance from each other. The lines formed in the paper by these wires are called water-marks; but, in the modern improvement of wove paper, these are avoided by using wire cloth woven in a loom, which, being tightly stretched over the frame, produces no water-mark. This mould is provided with another frame, called a *deckle*, which fits it exactly, and forms a boundary line to the sheet of paper, which would otherwise have a rough and jagged edge. This contrivance, by supplying an edge to the mould, gives it the character of a sieve, which enables the dipper, after he has dipped the mould into the vat, and taken in a sufficient quantity of the pulp, and given it a gentle motion to equalize its thickness, to drain the water away; he then removes the deckle, replaces it on another mould, and proceeds as before; while the second workman, the coucher, removes the sheet of paper thus made on to a felt, being a piece of woollen cloth, and then returns the mould to the dipper, who, in the meantime, has been operating with another mould, and forming another sheet: they thus exchange the moulds, the one dipping, and the other couching, until they have completed six quires of paper, which is called a *post*. When this quantity is completed, the heap is conveyed to the vat press, and subjected to heavy pressure. These six quires remain in the vat press until the dipper and the coucher have perfected another post, when they are removed to give place to it; and then the office of the third workman, the lifter, commences. He separates the sheets of paper from the felts, and forms them into a pile, which is again subjected to a second press, which detaches from them a great quantity of moisture. Here it remains until the workmen are prepared to replace it with a similar quantity, when it is taken to the drying rooms, and hung up on lines to dry. These lines are carefully covered with wax, both to prevent adhesion and contraction; and the opening of the windows should be strictly attended to, that the drying may not proceed too rapidly. This being accomplished, it is taken down, shaken, to make the dust fall out, and to separate the sheets from each other, and laid up in heaps ready to be sized. The size is prepared of a due consistence, twice filtered, and a portion of alum added. The workman dips a handful of the sheets, holding them open at the edges, that they may more equally imbibe the moisture, and after this process they are again subjected to the press. They are afterwards dried, sorted, brought under repeated and excessive pressure, and, finally, made up into quires and reams.

But as the process of paper-making must necessarily be comparatively slow when practised by hand, machinery has been resorted to, which has nearly supplanted the old method. We believe France has the honor of the invention, although it has been greatly improved in England by Messrs. Donkin and Co. That in most general use there is after Fourdrinier, who invented the endless web of wire. One of these machines can produce 25 superficial feet of paper per minute; and it is this which enables England to enter into competition with the foreign market, which it could not otherwise do, on account of the difference in the value of manual labor. In the old method, it took three months after receiving the rags into the mill to complete the paper: by the machine, they can receive the rags on one day, and deliver the paper made from them on the next.

The stuff, having been prepared and bleached in an expeditious manner by machinery, is emptied into the chest, or tub, as before, and from thence is delivered gradually into the vat, where it is kept in continual motion by means of revolving fans, called *hogs*. Nearly at the top of the vat there is a gate, which can be raised or lowered at pleasure, by means of which the flow of stuff is regulated on to the lip or trough, from which it falls upon the endless web of fine wire, which is kept continually moving in a horizontal direction over a series of revolving rollers, and is placed immediately under the hanging lip of the trough, so that the pulp may have the shortest distance possible to fall. These revolving rollers prevent the wire web from falling in or bagging, and keep it level; and as it is preserved at a due tenison from side to side, it has all the appearance of a table. A leather strap, or ledge of wood, on each side, forms the boundary line of the paper, answering the purpose of the deckle in the hand-making process; these are movable, according to the intended width of the paper. The long cascade or continuous stream of pulp, regulated with reference to the proposed thickness of the paper to be made, thus gently descends on this moving wire plane, which is perpetually travelling onward and onward; and, for its more perfect equalization, a second movement is resorted to, by means of a sort of crank, which gives the web a jerking motion at short intervals, and diffuses the liquid pulp unvaryingly over the surface. At the end nearest to the trough the pulp is, of course, perfectly fluid; but, as the web travels on, the moisture partially sinks through the fine apertures of the webbing, and the material coagulates. There has been a fashion prevalent of late years of having paper barred or ribbed: this appearance is given at this juncture. While yet moist, just before passing from the wire webbing, it is subjected to the pressure of a wire roller, which gives the indentations of the stripes or lines; this cylinder is called a *dandy;* from this it travels to a web of cloth or felt, during which advance it is subjected to heavy pressures, from passing between rollers covered with felt, and called the *pressing rollers.* This process answers to the wet press in the hand-made paper; and formerly this was the termination of the labors of the machines, the remaining work of drying, &c., being accomplished by hand. But an incalculable improvement took place in the addition of the drying rollers. These are three cylinders of polished metal, which effect in a few moments the perfect drying of the paper: while yet moist it passes over the first moderately warm; again over the second, of larger diameter, of greater warmth; and again over the third, with an augmented heat The paper is now perfectly dry, and any casual inequalities are removed from its surface. The final action of this wonderful machine is to wind the paper round a last roller or reel, which when full, is exchanged for another, and so on successively.

Here the work of the machine is finished; and the paper, being in long webs of many yards, requires to be cut into sheets. After different methods had been tried, a supplementary machine has been invented, which receives the web from off the reel on to a drum, cuts it into sheets of proper length with a circular knife, continually revolving, while the divided web proceeds; and these sheets are received and placed in regular heaps by children.

In this country, machining is more used than in Europe. In the year 1848, eight patents were granted for improvements in machines used in manufacturing, cutting, and performing other operations on paper.

One of these patents is for improved machinery for grinding the pulp. The machine much resembles mills for grinding grain. It is so arranged that the pulp is kept in circulation through the mill, passing in at the eye and out at the edges, until the whole is properly prepared.

In one of the machines patented, the paper is cut into sheets of any desired length, placed upon a table, and the edges adjusted for folding. To insure corresponding action throughout, the motions of various parts of the machine are taken from the cylinder which carries the knife.

Others of these machines cut the paper and drop it upon rods, over which it bends and hangs preparatory to folding.

The manufacture of the paper being thus completed, the sheets are separately examined, and every knot or blemish carefully removed, the torn or damaged ones being laid apart. In this state they are subjected to the action of a powerful press, in the full and open size of the sheet: they are afterwards cut round the edge, and then counted into quires of twenty-four sheets, which are folded in the middle, and put into reams, each ream containing twenty quires, of which the two on the outside are made up of twenty sheets each, from the damaged sheets that were thrown out. In this state they are again pressed, and finally tied up in wrappers.

India paper.—The material employed by the Chinese is the liber, or interior bark of a sort of mulberry, commonly called the paper-tree, and known to botanists under the name of *broussonetia papyrifera.* Kempfer has described the process pursued in China in the manufacture of this paper. Dr. Postans recently has described the material as the coarse hempen bagging used by the *bringarries,* when torn to rags in their service. These are cut, and well washed in tanks, near Kivzapone, in the Deccan. They are then bleached and dried: in twelve days they are converted into a pulp, which is then made into 4 lb. balls, about as big as a man's head. These are afterwards wet with water, and made into paper on a frame made of fine reeds, A man and a boy make the sheet, and a third man removes them, who first presses them under large stones to dry them, and then plasters them against the walls of the room to dry them. It is then coated with gum size, and polished with stones.

Rice paper.—The substance called in England, "rice paper," is made of the branch of the rice plant in China.

Mr. Gill remarks, that the Chinese "rice paper" is an organized vegetable production, much resembling, in its structure, the pith of elder. He thinks cylindrical pieces of elder or other pith might be found in any country, quite large enough to bear slicing in this manner; and which slices, after being flattened by pressure between plates (possibly warmed or heated) might serve as substitutes; and be as capable of receiving any colors.

Paper from the husks of Indian corn.—To 128 gallons of water put 10 quarts of good lime, or about 6 lbs. of good alkali, and place therein about 110 lbs. of clean corn-husks or flag-leaves. Let the water be moderately heated over a gentle fire, for two hours, when they will be ready for the engine, there to be worked, and managed, in every respect, as rags are for making paper.

Straw paper.—Take any quantity of straw, hay, or other vegetable substances, and boil it in a solution or ley of pot or pearl-ash, or other alkali or lime, in the following proportions, viz., to 115 lbs. of straw, hay, or other vegetable substance, add from 15 lbs. to 20 lbs. of the salts or ley of pot or pearl ash, or other alkali of lime, and boil them about 30 minutes, or steep the materials in the solution a few days, or until saturated, then draw off the water, and put them into a common engine, to be manufactured into paper, like rags.

Paper from wood.—Any wood may be reduced to shavings, which are thrown into a caldron of water, and set to boil. To every 100 lbs. of shavings, from 12 lbs. to 18 lbs. of any vegetable or mineral alkali (according to its strength) are to be added. 100 lbs. of wood will make from five to seven reams of paper.

Paper linen or *papier linge*, consists of paper made to resemble damask and other linen so closely, that it is impossible, without examination, to detect the difference: and, even to the touch, the articles made from the *papier linge* are very much like linen. The price is very low: a napkin costs only one cent; and, when they are soiled, they are taken back at half price. A good-sized table-cloth sells for 20 cents, and for the same price is sold a rouleau of paper, with one or two colors, for papering rooms, or for bed-curtains.

Oiled paper. Dr. Faraday, in his admirable volume on manipulations, states that hydrogen gas may be made with zinc, and dilute sulphuric acid in oiled paper, and conducted through paper tubes to a basin, as a trough, and received in oiled paper tubes. Also, that the steam of a tea-kettle may be conveyed in oiled paper tubes, so as to heat a steam-bath itself of oiled paper.

Paper tubes, to convey hot air, carbonic acid, or coal gas, may be made by rolling a sheet of paper, and tying it with thread. Gum, or paste, at the edges, makes it airtight, especially if varnished and corked.

Waxed paper.—Lay it on a clean hot plate, and rub it with wax tied in muslin.

Paper-hangings are in pieces of 12 yards long, by 20 inches wide, and printed by wooden blocks, with great rapidity. It is to be regretted that the splendid scenes and varied colors of French paper-hangings are not imitated elsewhere.

Sea-grass paper.—1, All rocks, roots, and shells, to be carefully separated from the grass. 2, The dust to be cleared from it, by beating it. 3, To be steeped in lime-water, in order to discharge the salt from it, and thus prevent decomposition. 4, To be partially pulverized, and then bleached perfectly white by oxy-muriate of lime. 5, To be made into pulp in the usual manner, by beating, or in a paper-engine.

PAPER PLOUGHING-MACHINE. This consists of a stout square board, the size of the paper, when cut; furnished, on the upper surface, with four deep grooves, one on each of the four sides, for guiding the plough. The plough itself is of a peculiar construction, in two parts; one part squaring upon the edge, and in the groove of the board; while the second portion carries the knife, and moves upon the first in a vertical direction. The paper to be cut being placed upon the cutting-bench, under the grooved board, the latter is brought down upon the paper by an iron-screwed rod, working between the board and a beam over head. The paper being firmly secured, and the upper board forming the gauge by which it is to be cut, the workman places the plough in one of the grooves, and moving it to and fro in an horizontal direction, effects the cutting of one edge of the paper; the plough is then transferred to another groove, and a second edge cut; a similar operation with the third edge completes the object.

As the paper is cut away, the knife descends, until the whole is taken off, and the parallelism of the knife is accurately maintained throughout; in this way the three sides of the paper are expeditiously cut, with one adjustment only; nor is the difficulty of putting in the paper so great as in the binders' common cutting-press.

PAPER HANGINGS. This important and elegant substitute for the ancient "hangings" of tapestry or cloth came into use about 200 years ago. The manufacture has undergone a gradual succession of improvements, and has now reached a high state of beauty and perfection. The patterns on these papers are sometimes produced by stencil plates, but more commonly by blocks, each color being laid on by a separate block cut in wood or metal upon a plain or tinted ground. The patterns are sometimes printed in varnish or size, and gilt or copper leaf applied; or bisulphuret of tin (*aurum musivum*) is dusted over so as to adhere to the pattern; and in what are called *flock papers*, dyed wools minced into powder are similarly applied. Powdered steatite, or French chalk, is used to produce the peculiar gloss known under the name of *satin*. Striped papers are sometimes made by passing the paper rapidly under a trough, which has parallel slits in its bottom through which the color is delivered; and a number of other very ingenious and beautiful contrivances have lately been applied in this important branch of art. The invention of the paper machine, by which any length of paper may be obtained, effected a great change in paper hangings, which could formerly only be printed upon separate sheets, and were much more inconvenient to print as well as to apply to the walls.

Originally the first method of making this paper was stencilling; by laying upon it, in an extended state, a piece of pasteboard having spaces cut out of various figured devices, and applying different water colors with the brush. Another piece of pasteboard with other patterns cut out was next applied, when the former figures were dry, and new designs were thus imparted. By a series of such operations, a tolerable pattern was executed, but with no little labor or expense. The processes of the calico printer were next resorted to, in which engraved blocks of the pear or sycamore were employed to impress the colored designs.

Paper-hangings may be distinguished into two classes; 1. those which are really painted, and which are designed in France under the title of *papiers peints*, with brilliant flowers and figures; and 2. those in which the designs are formed by foreign matters applied to the paper, under the name of *papier tontisse*, or flock paper.

The operations common to paper-hangings of both kinds, may be stated as follows:

1. The paper should be well sized.
2. The edges should be evenly cut by an apparatus like the bookbinder's press.
3. The ends of each of the 24 sheets which form a piece, should be nicely pasted together; or a Fourdrinier web of paper should be taken.
4. Laying the grounds, is done with earthy colors or colored lakes thickened with size, and applied with brushes.

An expert workman, with one or two children, can lay the grounds of 300 pieces in a day. The pieces are now suspended upon poles near the ceiling, in order to be dried. They are then rolled up and carried to the apartment where they are polished, by being laid upon a smooth table, with the painted side undermost, and rubbed with the polisher. Pieces intended to be satined, are grounded with fine Paris plaster, instead of Spanish white, and are not smoothed with a brass polisher, but with a hard brush attached to the lower end of the swing polishing rod. After spreading the piece upon the table with the grounded side undermost, the paper-stainer dusts the upper surface with finely powdered chalk of Briançon, commonly called calc, and rubs it strongly with the brush. In this way the satiny lustre is produced.

The laying on of colors is accomplished in precisely the same way as in calico printing, either by *block press* printing, or by the cylinder machine. With the latter, 18,000 yards a day are printed; these are afterwards cut into pieces 12 yards long. The great length to which paper is now made, in some cases 2,800 feet long, facilitates very much the working of this machine.

PAPIER-MACHE. A name given to articles manufactured of the pulp of paper, or of old paper ground up into a pulp, bleached, if necessary, and moulded into various forms. This article has lately been used upon an extensive scale for the manufacture of mouldings, rosettes, and other architectural ornaments; pilasters, capitals, and even figures as large as life, have also been made of it. It is lighter, more durable, and less brittle and liable to damage than plaster, and admits of being colored, gilt, or otherwise ornamented. Another article sometimes goes under the same name which is more like pasteboard, consisting of sheets of paper pasted or glued, and powerfully pressed together, so as to acquire, when dry, the hardness which it possesses. It is afterwards varnished with japan or other varnish, and often beautifully ornamented by figures, landscapes, &c., occasionally inlaid with mother of pearl; a mixture of copperas, quicklime, and glue, makes it partially waterproof; and borax and phosphate of soda, which is also added, tends to make it fire-proof.

PAPIER VEGETABLE. The best kind of tracing paper, permitting either the use of ink or black-lead pencil; besides being of a purer color than any other, is obtained in France from the root of the *althæa officinalis*.

PARAFINE. A substance contained in the products of the distillation of the tar of beech wood. It is a tasteless inodorous fatty matter, fusible at 112°, and resists the action of acids and alkalis. It appears to be a hydro-carbon. Its name is compounded of parum, *little*, and affinis, *akin*, to denote the remarkable chemical indifference which is its characteristic feature. A similar substance has been obtained by Dr. Christison from the petroleum of Rangoon.

PARACHUTE. An apparatus resembling the common umbrella, but of far greater extent, intended to enable an aëronaut, in case of alarm, to drop from his balloon to the ground without sustaining injury. This is effected by means of the resistance of the atmosphere. When the parachute is detached from the balloon, and abandoned with its load in the air, it must proceed at first, from the continued action of gravity, with an accelerated motion, until the increased velocity produces a resistance equal to the force of attraction, or the weight of the apparatus with its load. After this equilibrium has been attained, the parachute will descend with a nearly uniform velocity. According to theory, this terminal velocity, supposing the surface of the parachute to be flat, is equal to that which a heavy body would acquire in falling though the altitude of a column of air incumbent on that surface, and having the same weight as the whole apparatus. A circular parachute having a diameter of 80 feet, and weighing with its load 225 pounds, would acquire a terminal velocity of about 18 feet per second; and a person descendiug with it at this rate would receive the same shock on reaching the ground as if he dropped freely from a height of 2½ feet. The actual resistance of the air is, however, greater than is given by theory, and is, besides, augmented by the concavity of the parachute, which occasions an accumulation of the fluid; but, on account of the action of the wind, the axis of the parachute will probably become inclined to the vertical, in which case the resistance will suffer a diminution.

One of the most remarkable instances of descent from a great height with a parachute is that of Garnerin, a Frenchman, who ascended in a balloon from London, on the 2nd of September, 1802. After hovering seven or eight minutes in the atmosphere, he cut the cord by which his parachute was attached to the balloon. It instantly expanded, and for some seconds descended with an accelerating velocity, till it became tossed extremely, and took such wide oscillations that the basket or car was at times thrown almost into a horizontal position. The intrepid aëronaut narrowly escaped destruction by being precipitated on the houses in St. Pancras, and at last fortunately came to the ground in a neighboring field. He seemed to be much agitated, and trembled exceedingly at the moment he was released from the car.

A recent experiment of this kind, made by Mr. Cocking, was attended with fatal consequences. Having conceived a notion that the vibration might be avoided by giving the machine a different form, this projector constructed one in the form of an inverted umbrella, that is, having the concave side uppermost, and bound to a strong wooden hoop to prevent its collapse in the descent. The diameter of the hoop was 34 feet; and there was also a hole of 6 feet in diameter in the middle of the parachute, which, it was supposed, would also contribute to give greater steadiness. Having attached himself to this machine, he ascended from Vauxhall Gardens on the 24th of July, 1837. On being cut away from the balloon the parachute descended rapidly, and with violent oscillations: the hoop broke, and the unfortunate projector fell, dreadfully mangled, at Lee, near Blackheath. The persons in the car of the balloon were also placed in great danger, having narrowly escaped suffocation from the quantity of gas expelled in consequence of the great velocity with which the balloon darted upwards immediately on being liberated from the parachute. They suffered extreme pain, and for a time were deprived of sight; but fortunately they had carried up with them a large bag filled with atmospheric air, by means of which they were enabled to breathe. Without this, they would probably have perished. Since then safe descents have been made with the parachute both in England and France.

Latterly, use has been made of these instruments in making descents in coal mines. Occasionally the rope breaks and injury arises. By one of these being attached, when an accident occurs it unfurls, and breaking the force of the fall enables those descending to reach the bottom in security.

PARAPET, or BREAST-WORK. In fortification, a wall or screen raised on the extreme edge of a rampart or other work, through which embrasures or openings are cut for the cannons to fire through. The solid parts of the parapet, between the embrazures, are called the *merlons*. In common language, a parapet is a breast-wall, raised on the edges of bridges, quays, &c., to prevent people from falling over.

PARALLEL MOTION is a very important principal in mechanics; that by which the motion of a piston is rendered a rotatory action, and a rotatory motion a rectilinear one; so that, if we get power, we may, by this means, apply it in the way desired. The crank of the old spinning-wheel is the most common method, but it causes the piston-rod to *wabble*. To prevent this *wabbling* has been the subject of much contrivance. White's American is most ingenious. He connects the piston with the inner of two wheels, which works inside an outer one of double its size, and goes twice round the outer, in an epicycloid equal to the diameter of the outer, which is upon an axis connected with the works. Another plan is, to connect the piston-rod by a bar, with a rotating crank, which revolves the axle.

PARING AND BURNING. The operation of paring off the surface of worn-out grass land, or lands covered with coarse herbage, and burning it for the sake of the ashes, and for the destruction of weeds, seeds, insects, &c. Agriculturists differ as to the value of this mode of improving land; the greater number preferring a naked fallow even for one or two years, alleging that more injury is done by the vegetable matter lost in burning, than benefit obtained by the ashes produced. Where the object is to bring land abounding in coarse herbage immediately into a state of good culture, paring and burning is evidently the most rapid mode that can be employed; and if the soil contains calcareous matter, burning will have nearly the same effect on it as if a dressing of quicklime had been applied. Much, however, depends on the way the land is treated afterwards.

Whether land requires, and will be benefitted by paring and burning, depends upon its condition: if it be full of weeds, and have an abundance of vegetable matter, and especially if that organic matter be in an acid and sour state, or in any way peaty, then paring and burning the soil will be a great means of fertilizing the land; but it is a great impoverisher, and should never supply the place of manure, nor should it be practised except under the above conditions.

PARCHMENT. This writing material has been known since the earliest times, but is now made in a very superior manner to what it was anciently. The art of making parchment consists in certain manipulations necessary to prepare the skins of animals of such thinness, flexibility and firmness, as may be required for the different uses to which this substance is applied. Though the skins of all animals might be converted into writing materials, only those of the sheep or the she-goat are used for parchment; those of calves, kids, and dead-born lambs for vellum; those of the he-goat, she-goat, and wolves for drum-heads; and those of the ass for battle-doors. All these skins are prepared in the same way, with slight variations.

They are first of all prepared by the leather-dresser. After they are taken out of the lime-pit, shaved, and well washed, they must be set to dry in such a way as to prevent their puckering, and to render them easily worked. The small manufacturers make use of hoops for this purpose, but the greater employ a *herse*, or stout wooden frame. This is formed of two uprights and two cross-bars solidly joined together by tenons and mortises, so as to form a strong piece of carpentry, which is to be fixed up against a wall. These four bars are perforated all over with a series of holes, of such dimensions as to receive slightly tapered, box-wood pins, truly turned, or even iron bolts.

Each of these pins is transpierced with a hole like the pin of a violin, by means of which the strings employed in stretching the skin may be tightened. Above the *herse* a shelf is placed for receiving the tools which the workman needs to have always at hand. In order to stretch the skin upon the frame, larger or smaller skewers are employed, according as a greater or smaller piece of it is to be laid hold of. Six holes are made in a straight line to receive the larger, and four to receive the smaller skewers or pins. These small slits are made with a tool like a carpenter's chisel, and of the exact size to admit the skewer. The string round the skewer is affixed to one of the bolts in the frame, which are turned round by means of a key, like that by which pianos and harps are tuned. The skewer is threaded through the skin in a state of tension.

Every thing being thus prepared, and the skin being well softened, the workman stretches it powerfully by means of the skewers; he attaches the cords to the skewers, and fixes their ends to the iron pegs or pins. He then stretches the skin, first with his hand applied to the pins, and afterwards with the key. Great care must be taken that no wrinkles are formed. The skin is usually stretched more in length than in breadth, from the custom of the trade; though extension in breadth would be preferable, in order to reduce the thickness of the part opposite the backbone.

The workman now takes the fleshing tool represented under CURRYING. It is a semicircular double-edged knife, made fast into a double wooden handle. The workman seizes the tool in his two hands, so as to place the edge perpendicularly to the skin, and pressing it carefully from above downwards, removes the fleshy excrescences, and lays them aside for making glue. He now turns round the *herse* upon the wall, in order to get access to the outside of the skin, and to scrape it with the tool inverted, so as to run no risk of cutting the epidermis. He thus removes any adhering filth, and squeezes out some water. The skin must next be ground. For this purpose it is sprinkled upon the fleshy side with sifted chalk or slaked lime, and then rubbed in all directions with a piece of pumice-stone, 4 to 5 inches in area, previously flattened upon a sandstone. The lime gets soon moist from the water contained in the skin. The pumice-stone is then rubbed over the other side of the skin, but without chalk or lime. This operation is necessary only for the best parchment or vellum. The skin is now allowed to dry upon the frame; being carefully protected from sunshine, and from frost. It is afterwards scraped, rubbed, and polished with pumice. It is occasionally colored green with a mixture of cream of tartar, verdigris, and nitric acid, and finally receives a gloss from the white of egg or mucilage, laid on with a brush.

PARTING. A process for separating gold from silver. (*See* ASSAY, REFINING, and SILVER.)

PASTE. In gem sculpture a preparation of glass, calcined crystal, lead, and other ingredients, for imitating gems. This art was well known to the ancients, and after being long lost, was restored, at the end of the fifteenth century, by a Milanese painter.

Some modern artists have succeeded in obtaining a composition possessing a hard, fine, and brilliant lustre or appearance; but *pastes*, or mock diamonds as they are called, depend most for brilliancy on the art displayed in setting the foil or tinsel behind them. Several recipes have been given by M. Fontanier; but the most useful, and that generally employed for the production of artificial diamonds, is the following: Take of litharge 20 parts, of silex 12, of nitre 4, of borax 4, and of white arsenic 2 parts. These ingredients are to be well mixed together in a crucible and melted; the fused metal is thrown into water; and should any of the lead employed be reduced to the metallic state, it becomes separated by this process and the glass is remelted for use. For the finer kinds rock crystal is used instead of flint or sand, as it occurs in a much purer state; *i. e.*, more free from the admixture of metallic oxides, which give to vitreous compounds their different colors. In place of the above, Loysel recommends the following ingredients to form a compound, having the same specific gravity as the oriental diamond, and on this account considered superior, as it more nearly approaches the gem with regard to its refractive and dispersive powers; but, like the former, it requires to be kept for some two or three days in a fused state, in order to expel the superabundant alkali and to perfect the refining. A moderate degree of heat fuses it. The following is its composition: Take of white sand purified by being washed, first in muriatic acid, and afterwards in pure water, until all traces of acid are removed, 100 parts; red oxide of lead (minium) 150 parts; calcined potash 30 to 35 parts; calcined borax 10; and oxide of arsenic 1 part.

The term paste is also applied to the earthy mixture for pottery and porcelain; also to dough, and to the solution of starch or wheat flour, made by first mixing it with a proper portion of cold water, and then adding boiling water under constant stirring, so as to form an even solution. Alum is often added to paste to strengthen it.

PASTEL. In painting, a crayon formed with any color and gum water, for painting on paper or parchment. The great defect of this mode of painting is its want of durability. (*See* CRAYON).

PASTIL. In pharmacy, a kind of lozenge. A compound of charcoal with odoriferous substances, which diffuses an agreeable perfume during its slow combustion.

PASTES, or FACTITIOUS GEMS. The general vitreous body called Strass (from the name of its German inventor,) preferred by Fontanier, is prepared in the following manner:—8 ounces of pure rock-crystal or flint in powder, mixed with 24 ounces of salt of tartar, are to be baked and left to cool. The mixture is to be afterwards poured into a basin of hot water, and treated with dilute nitric acid till it ceases to effervesce; and then the frit is to be washed till the water comes off tasteless. This is to be dried, and mixed with 12 ounces of fine white lead, and the mixture is to be levigated and elutriated with a little distilled water. An ounce of calcined borax being added to about 12 ounces of the preceding mixture in a dry state, the whole is to be rubbed together in a porcelain mortar, melted in a clean crucible, and poured out into cold water. This vitreous matter must be dried, and melted a second and a third time, always in a new crucible, and after each melting poured into cold water, as at first, taking care to separate the lead that may be revived. To the third frit, ground to powder, 5 drachms of nitre are to be added; and the mixture being melted for the last time, a mass of crystal will be found in the crucible, of a beautiful lustre. The diamond may be well imitated by this Mayence base. Another very fine white crystal may be obtained, according to M. Fontanier, from 8 ounces of white lead, 2 ounces of powdered borax, ¼ grain of manganese, and 3 ounces of rock-crystal, treated as above.

The colors of artificial gems are obtained from metallic oxides. The *oriental topaz* is prepared by adding oxide of antimony to the base; the amethyst, by manganese with a little of the purple of Cassius; the beryl, by antimony and a very little cobalt; yellow artificial diamond and opal, by horn-silver (chloride of silver;) blue-stone or sapphire, by cobalt. The following proportions have been given:—

For the *yellow diamond*. To 1 ounce of strass, add 24 grains of chloride of silver, or 10 grains of glass of antimony.

For the *sapphire*. To 24 ounces of strass, add 2 drachms and 26 grains of the oxide of cobalt.

For the *oriental ruby*. To 16 ounces of strass, add a mixture of 2 drachms and 48 grains of the precipate of Cassius, the same quantity of peroxide of iron prepared by nitric acid, the same quantity of golden sulphuret of antimony and of manganese calcined with nitre, and 2 ounces of rock crystal. Manganese alone, combined with the base in proper quantity, is said to give a ruby color.

For the *emerald*. To 15 ounces of strass, add 1 drachm of mountain blue (carbonate of copper), and 6 grains of glass of antimony; or, to 1 ounce of base, add 29 grains of glass of antimony, and 3 grains of oxide of cobalt.

For the *common opal*. To 1 ounce of strass, add 10 grains of horn-silver, 2 grains of calcined magnetic ore, and 26 grains of an absorbent earth (probably chalk-marl.)

M. Douault Wiéland, in an experimental memoir on the preparation of artificial colored stones, has offered the following instructions, as being more exact than what were published before.

The base of all artificial stones is a colorless glass, which he calls *fondant*, or flux; and he unites it to metallic oxides, in order to produce the imitations. If it be worked alone on the lapidary's wheel, it counterfeits brilliants and rose diamonds remarkably well.

This base or strass is composed of silex, potash, borax, oxide of lead, and sometimes arsenic. The silicious matter should be perfectly pure; and if obtained from sand, it ought to be calcined and washed, first with dilute muriatic acid and then with water. The crystal or flint should be made redhot, quenched in water, and ground, as in the potteries. The potash should be purified from the best pearl-ash; and the borax should be refined by one or two crystallizations. The oxide of lead should be absolutely free from tin, for the least portion of this latter metal causes milkiness. Good red lead is preferable to litharge. The arsenic should also be pure. Hessian crucibles are preferable to those of porcelain, for they are not so apt to crack and run out. Either a pottery or porcelain kiln will answer. and the fusion should be continued 24 hours; for the more tranquil and continuous it is, the denser is the paste, and the greater its beauty.

For rubies, the proportions are:—Paste 2,800; oxide manganese 70.

For emerald:—Paste 4,608; green oxide copper 42; oxide crome 2.

PATENT YELLOW. A pigment obtained by fusing a mixture of oxide and chloride of lead.

PAVEMENT FOR ROADS. As the advantages of good roads through the country are unquestionable, so the benefits of well paved streets in cities are no less apparent. Good roads are an evidence of civilization. The Indian follows the trail of his forefather, and gives evidence of some kindred instinct like the brute, but the civilized man levels the mountain and fills up the morass, to make a permanent pathway for the horse and his rider, the carriage and its driver. The importance of good roads was not unknown to the ancients, and to the Carthagenians, a commercial people, is the invention of paved roads traced. From them the Romans learned the art as they did that of ship-building. During the reign of Julius Cæsar, the Capital was in communication with the chief towns by well paved roads which branched from the seven-hilled city, at one time, to every province of the empire. The Romans introduced their system of roads into Britain, and they were made upon a gigantic scale, with an eye to permanency, it being the common opinion then that the Roman Empire was to endure for ever.

The Perrine pavement lately laid down in New-York is a pavement made of oblong blocks of trap, each of about 10 inches long, and six broad, and six deep, neatly trimmed. The ground is excavated about 14 inches, and a strata of 4 inches gravel mixed with sand and some plaster of Paris is laid down and well beetled and levelled and then sprinkled with water. Then another strata is laid down of the same stuff and treated in the same way, making it slightly convex. On the top of this these oblong blocks are laid in among a bed of sand mixed with ground burnt brick. These blocks must be accurately laid and well rammed down, and in our opinion will make the best pavement for a business city like New-York, where there is an immense amount of travel.

The idea of paving the streets of modern cities is derived from, and based upon the Roman roads. Many of these are still in perfect repair in Italy, especially in the neighborhood of Rome. The stones are generally of trap rock, of a polyangular shape, of a very large surface, and about fourteen inches deep. They are slightly pyramidal, and set with their broad faces upwards. They are well fitted together, and sometimes laid in cement, though not always. In Naples, the blocks are rectangular (mostly square) of about two feet, by two surface, and six inches in thickness, well fitted together, placed diagonally on the street, and laid in a thick bed of Roman cement. This pavement excels in solidity and evenness, but becomes dangerously smooth, hence it is necessary, from time to time to cut grooves on its surface. The city of Rome is paved with blocks which are parallelograms, of about ten inches square surface. They are laid in a thick bed of cement. In the cities of Northern Italy, the roads may be called stone railroads, as the tracks for the wheels are broad flat stones, laid with precision, while the tracks for the horses' feet, between the lines, are paved with small stones. This is a good pavement, when well made, and was partially carried out on the great turnpike between the cities of Albany and Schenectady, in New-York. None of these kinds of pavements are suitable for such a city as New-York.

A great number of different kinds of pavements have been tried in New-York city. The cobble stone or small boulder pavement, is the oldest, and not a bad pavement when well laid down, but this is seldom the case, and one great difficulty in the way of its endurance, is the great variety in the quality of the stones. Wooden blocks were at one time supposed to be the best of all pavements, before their enduring qualities were tried. The pavement which has got the name of "Russ" in this city, is nothing more nor less than the Neapolitan pavement, only its pozzoloni bed of concrete, for the diagonal blocks, is made in sections. It will soon have to be treated in this city, after it becomes smooth, like the pavement in Naples. This is the only objection to it, but is a very serious one.

Pavement with rough tops is best for steep inclines, to allow horses to pull heavy loads up the same, and although not required in such a city as New-York, it may be good for some other city. The Perrine pavement is not suitable for streets like Broadway, where the carriages and omnibusses will be continually crossing the tracks, and it will be expensive for repairs, because there is so much street lifting for gas pipes and common sewers. The Russ and Perrine pavements are solid and lasting, but we must look to a pavement that will be enduring, easily repaired, easily laid down, and that will obviate the surface difficulties of the two pavements mentioned.

A new system has been tried in London, and has been tested for ten years with the most gratifying results. This method is to remove the subsoil to the depth of sixteen inches, then lay a layer of 4 inches of strong gravel, well rammed down, then another layer of gravel, and a little chalk is well rammed, and a third of the same stuff, all well rammed, and the street made slightly rounding. Stones of good granite four inches deep, three inches thick, and four inches long, are then laid down in fine sand, each carefully placed not to rock in its bed, and the whole surface well rammed down. This system has been found, by thorough experience, to be infinitely preferable to the large blocks, and for that reason it is well worthy of the attention of our city authorities.

PEARL ASH. The common name for carbonate of potash.

PEARL BARLEY, is common barley deprived of its husk and rounded, and polished in a mill.

PEARL POWDER is a watery precipitate of the nitric solution of bismuth, with the addition of muriatic acid. Sulphuretted hydrogen, or coal gas, turns it black.—*Or*, with fine powder of French chalk mix an equal weight of magistery of bismuth.

PEARLS. These are substances formed by certain bivalve mollusks, consisting of concentric layers of a fine compact nacre, or substance identical with that which lines the inside of the shell; they are sometimes found free and detached within the lobes of the mantle, but most commonly adherent to the nacrous coat of the shell, which on that account is termed "mother of pearl." The species of bivalve which produces the most valuable pearls is the pearl oyster of Ceylon, *Meleagrina margaritifera*, Lam. A pure piece is generally spherical, and has a white, or bluish, or yellowish white color, with a peculiar lustre and irridescence, and consists of alternating concentric layers of membrane and carbonate of lime. When steeped in dilute muriatic acid, the carbonate is decomposed with effervescence, and films of membrane remain undissolved.

Pearls were in the highest possible estimation in ancient Rome, and bore an enormous price. Their cost in modern times has very much declined; partly, no doubt, from changes of manners and fashions, but more, probably, from the admirable imitations of pearls that may be obtained at a very low price. According to Mr. Milburn, a handsome necklace of Ceylon pearls, smaller than a large pea, cost from $850 to $1,500, but one of pearls about the size of peppercorns may be had for $75; the pearls in the former sell at 5½ dollars each, and those in the latter at about 37½ cents. When the pearls dwindle to the size of a small shot, they are denominated *seed* pearls, and are of little value. They are mostly sent to China. One of the most remarkable pearls of which we have any authentic account was bought by Tavernier, at Catifa, in Arabia, a fishery famous in the days of Pliny, for the enormous sum of $50,000! It is pear-shaped, regular, and without blemish. The diameter is ·63 inch at the largest part, and the length from 2 to 3 inches. It is in the possession of the shah of Persia.

The pearl oyster is fished in various parts of the world, particularly on the west coast of Ceylon; at Tuticorin, in the province of Tinnevelly, on the coast of Coromandel; at the Bahrein Islands, in the Gulf of Persia; at the Sooloo Islands; off the coast of Algiers; off St. Margarita, or Pearl Islands, in the West Indies, and other places on the coast of Colombia; and in the Bay of Panama, in the South Sea. Pearls have sometimes been found on the Scotch coast, and in various other places.

The pearl fishery of Tuticorin is monopolized by the East India Company, and that of Ceylon by Royalty. But these monopolies are of no value, as in neither case does the sum for which the fishery is let equal the expenses incurred in guarding, surveying, and managing the banks. It is therefore sufficiently obvious that this system ought to be abolished, and every one allowed to fish on paying a moderate licence duty. The fear of exhausting the banks is quite ludicrous.

The fishery would be abandoned as unprofitable long before the breed of oysters had been injuriously diminished, and in a few years it would be as productive as ever. Besides giving fresh life to the fishery, the abolition of the monopoly would put an end to some very oppressive regulations enacted by the Dutch more than a century ago.

PEARLS, ARTIFICIAL. These are small globules or pear-shaped spheroids of thin glass, perforated with two opposite holes, through which they are strung, and mounted into necklaces, &c., like real pearl ornaments. They must not only be white and brilliant, but exhibit the iridescent reflections of mother of pearl. The liquor employed to imitate the pearly lustre, is called the *essence of the East* (*essence d'orient*), which is prepared by throwing into water of ammonia the brilliant scales, or rather the *lamellæ*, separated by washing and friction, of the scales of a small river fish, the blay, called in French *ablette*. These scales digested in ammonia, having acquired a degree of softness and flexibility which allow of their application to the inner surfaces of the glass globules, they are introduced by suction of the liquor containing them in suspension. The ammonia is volatilized in the act of drying the globules.

Some manufacturers employ ammonia merely to prevent the alteration of the scales; that when they wish to make use of them they suspend them in a well clarified solution of isinglass, then pour a a drop of the mixture into each bead, and spread it round the inner surface. It is doubtful whether, by this method, the same lustre and play of colors can be obtained as by the former. It seems, moreover, to be of importance for the success of the imitation, that the globules be formed of a bluish, opalescent, very thin glass, containing but little potash and oxide of lead. In every manufactory of artificial pearls, there must be some workmen possessed of great experience and dexterity. The French excel in this ingenious branch of industry.

PEARL WHITE is a submuriate of bismuth, obtained by pouring a solution of the nitrate of that metal into a dilute solution of sea salt, whereby a light and very white powder is obtained, which is to be well washed and dried. *See* BISMUTH.

PEARLSINTER. In mineralogy, a siliceous mineral found in volcanic tufa: it is also called *fiorite*.

PEARLSTONE. A variety of obsidian, a volcanic product of a pearly lustre: it is a silicate of alumina.

PEASTONE, or PISOLITE. A variety of limestone composed of globular concretions the size of a pea.

PEAT. The natural accumulation of vegetable matter on the surface of lands not in a state of cultivation; always more or less saturated with water, and generally abounding in modifications of extractive matter, varying with the nature of the plants of which the peat is composed.

Peat is generally of a black or dark brown color, or, when recently formed, of a yellowish brown: it is soft, and of a viscid consistence; but it becomes hard and darker by exposure to the air. It is generally more or less mixed with earthy substances. When steeped in water it gives out a brown liquor, more or less dark. When thoroughly dried it may be set fire to, and burns slowly, giving out a gentle heat without much smoke. This smoke communicates a peculiar flavor to all the articles with which it comes in contact; and this flavor is considered a characteristic of spirits which have been distilled in vessels heated by this kind of fuel, and also of malt, corn, and fish which have been dried by it. Peat abounds in every part of the world, but more especially in the cold moist climates of temperate regions, and generally in those parts of Europe where the ground is moist without natural drainage, and where the sun's light is obscured by clouds. It covers many thousand acres in Ireland, and in the Highlands and western counties of the Lowlands of Scotland, and in the western counties of England; but all these bogs are rapidly disappearing, in consequence of being drained, and having their surfaces slightly covered with earth, and stirred and sown with grass seeds.

When peaty matter accumulates on the sides of acclivities it is generally comparatively dry, and is then called hill-peat; but when peat accumulates on hollow places, or on flat surfaces, it is generally thoroughly saturated with water, and is then called peat-bog. In most cases the principal plant which forms the peatty matter is the *Sphagnum palustre* of Linnaeus; a moss which is common on all moist peaty surfaces throughout Europe, and is frequent in many parts of North America. This moss continues growing upwards from the points of the shoots, while decay is advancing in a similar manner from their lower extremities; thus forming a thick, close mass of vegetable matter, which rots below as it increases in height. The rotten part is frequently dug out and dried, to be used as fuel, or to be mixed with dung or lime and rotted into manure.

When peaty matter accumulates on a surface which abounds in springs, the water sometimes oozes out beneath the peat, and between it and the natural soil, in such quantities as to raise up the layer of peat, and float it off to a distance; sometimes carrying every thing before it, and ending by burying under it lands in a state of culture. About the middle of the 18th century, a remarkable irruption of this kind took place near Annan in Dumfries-shire; and such irruptions are frequent in Ireland. The circumstances favorable to the growth of peat are a soil abounding in springs, a flat surface or hollow surrounded by hills, and a moist climate. Hence peat-bogs are more abundant in Ireland, and in the western counties of Scotland, than in any other part of the British empire.

When an accumulation of peat has taken place in a level situation, or on an acclivity not abounding in springs, the matter accumulated is comparatively dry, and is then called peat moss. One of the most remarkable peat mosses in Britain is the Flanders Moss, in Stirlingshire. It rests on a flat surface of excellent alluvial soil, of which it covers about 4000 acres. Great part of this peat moss, being quite light, has been cut into small pieces, and floated off, by means of a stream of water, to the sea; thus exposing the natural soil, and rendering it fit for culture. This operation was commenced at Blair-Drummond, towards the end of the last century, by the celebrated Lord Kaimes, and is still continued by his son, Mr. Drummond.

PEATS, *Turf.* Peat bog cut out in small square or rectangular pieces, and dried for being used as fuel. These pieces are cut out with light spades in the summer season, spread abroad to dry, and afterwards carted home and put up in stacks or heaps, which are thatched to exclude the rain. These peats are afterwards used as fuel, not only for domestic purposes, but for burning lime, and for heating kilns for drying corn, &c. To facilitate the drying of peat the water is sometimes pressed out of the square pieces after they are cut, and thrown out of the bog, by a compressing machine, which also renders the material more compact and durable in the fire. Peats are also sometimes charred by a smothered combustion, so as to be rendered better adapted to serve as a substitute for pit-coal, coke, or charcoal, in smelting iron or other metals, in generating steam, &c. Attempts have been made to separate astringent matter from peat, and to use it in tanning leather.

PEAT SOIL. Peat in a state of decomposition, on which corn or other agricultural crops may be grown. The process of turning living peat into peat soil is greatly facilitated by draining, and by laying earth or lime on its surface, and afterwards mixing the earthy matter with the peaty by ploughing or digging. In this manner every kind of peaty surface may be rendered available for agricultural purposes; and accordingly, in Ireland, good crops of corn, potatoes, and artificial grasses are produced on the surface of peat lands, which consist of a layer of peat from five to twenty feet in depth. The plants which thrive best on the surface of beds of peat of this description are those which extend their roots immediately under the surface. Hence few trees will thrive in such soils, with the exception of the spruce fir, the silver fir, the birch, and two or three kinds of willows. Peaty soil is extensively used in gardening, in the culture of plants which are found growing on this soil in a wild state.

Peat is not extensively found in the United States. The light soil and the extensive clearings in New-England have prevented accumulations of vegetable matter. Peat is common in Maine and the Canadian border, and many of the swamp mucks of New-York, New-Jersey, and Pennsylvania, contain as much peaty matter as the bogs of Ireland, and might be cut and dried for fuel.

Charred peat is among the best of deodorizers, from the absorbent property of the finely-divided charcoal, hence its value when added to night-soil to make compost manure. Some time since a company was started in Ireland to manufacture out of peat and turf, naphtha, parafine, volatile oil, and salts of ammonia, with considerable profit. Small quantities of these substances are obtained by the close distillation of peat, but not the profitable return calculated on by overdrawn estimates. The charcoal of peat is that best adapted for the manufacture of gunpowder.

Peat from wood, or *woody peat*, is a composition of the branches, trunks, and roots of trees, with their leaves, and the shrubs and plants which have grown up among them, which have lain so long in water as to have decayed into a mass soft enough to be cut with a spade. The color is a blackish brown, like that of mossy peat; and it may be used as manure, for fuel, and for the growth of plants. It is abundant in North America, where it forms the soil in which many of the plants and trees of that country thrive with the greatest vigor. Wherever it can be found it is the most suitable of all kinds of peat for garden purposes. This kind of peat is frequently burned for its ashes; and these, from the alkali they contain, are found an excellent manure.

Peat, sandy, or *sandy peat*, is mossy peat in a state of decay or mould, naturally mixed with sand brought over it, from soil lying above its level, or by the overflowings of rivers. It is used in gardening for the same purposes as heath soil.

PECTIC ACID is the acid of jellies. Take any quantity of carrots; wash and cleanse them well, then, by means of a rasp, reduce them to a pulp; express this strongly, and wash the marc with distilled or filtered rain-water until it cease, by expression, to be colored. Mix fifty parts of the washed marc, expressed, with 800 parts of distilled water, and 1 part of a solution of caustic potash; then heat the mixture till it boil, and let it boil for a quarter of an hour, or until a portion of the fluid coagulate completely into a jelly with an acid. Pass, now, the boiling liquor through a cloth, and wash the mass with distilled or filtered rain-water, mixing these washings, passed through the cloth, with that which was strained while hot. The mixed fluid should become thick and gelatinous on cooling. This contains a pectate of potash, which may be decomposed by a small quantity of muriate of lime, largely diluted with distilled water, by which means an insoluble gelatinized pectate of lime is formed, which should be well washed on a cloth. The washed pectate is next to be boiled, for a few minutes, with distilled water, acidulated with muriatic acid, to dissolve the lime and the starch; and, by throwing the whole on a cloth, and washing it with distilled water, the pectic acid is procured.

PEDOMETER. An instrument in the shape of a small watch which enables a person to tell over what space of ground he has walked or ridden. It is so constructed that when the body of the traveller is raised either by the spring of his foot or the motion of his horse, a lever is made to act upon the wheel work of the instrument, and an index or hand on the dial plate points to the figures which indicate the number of miles passed over.

PELTRY is nearly synonymous with fur, and comprehends the skins of different kinds of wild animals that are found in high northern latitudes, both of this and the European continent; such as the beaver, bear, moosedeer, marten, mink, sable, wolverine, wolf, &c. When these skins have received no preparation but from the hunters, they are most properly called peltry; but when they have had the inner side tawed or tanned by an aluminous process, they may then be denominated *furs*.

The scouring or cleaning of peltry is performed in a large cask, or truncated cone laid on its side, and traversed by a revolving shaft, which is furnished with a few rectangular rounded pegs. These are intended to stir round the skins, while they are dusted over with Paris plaster, whitening, or sometimes sand, made as hot as the hand can bear. The bottom of the cask should be grated, to allow the impurities to fall out. The *lustrage*, which the cleansed skins next undergo, is merely a species of dyeing, either topical, to modify certain disagreeable shades, or general, to impart a more beautiful color to the fur.

PENCILS, Black Lead, Manufacture of. The best pencils of this kind are made from a natural ore, *plumbago*, but there are other kinds made of plumbago-dust and antimony. The lumps of pure plumbago, when scraped from dirt, are generally of an irregular form, not of a large size. These lumps are cut into thin slices by a circular saw, each slice being sawn by a gauge to its proper thickness. The saw runs vertically and the plumbago is fed below it, the workmen gradually raising it, until the slice is cut off, where it falls down slice upon slice of different sizes, upon a table below. One edge is then made straight with a shaving tool, and it is then fit to be inserted into the wood. The wood is cedar, in half squares cut by a circular saw into the lengths of the pencil. A groove is cut by a proper gauge plane into one side of the wood square, and the workman takes a piece of the cut plumbago, with its edge made straight, and dips it into strong glue and then inserts it into the groove, and then with a very sharp instrument makes a slight cut at each end and gives the plumbago a slight snap, when it breaks off with a clean straight edge. This is again dipped in the glue and operated like the other piece, until the whole slice is used up or the pencil groove filled, when the whole surface is smoothed along and the two pieces are firmly glued together, forming a rough square pencil.

To make it round, it is first forced through a square hole in a steel puppet, by the workman; and on the other side of this puppet, there is a small planing tool revolving on a centre, with two gauges on it, to turn it round and to the exact size. As soon as the end of the pencil projects from the finishing gauge of the cutters, it is forced into a circular hole in a steel plate, through which it is drawn with a pair of wooden nippers, and it comes out beautifully round polished. It is polished by the outer end of the circular hole being smaller than the the inner, which thus compresses and polishes the wood.

Ever-Pointed Lead. The round pieces of lead for pencil cases are first sawed into small square pieces, and they are then made round by forcing them lengthways through three circular holes of different sizes cut in pieces of ruby. In passing through the first hole, only the four angles of the prism are cut off, and it is then octagonal; the next hole is smaller, and it takes off these eight angles and it then becomes a prism of sixteen sides; and in the next passage through the small hole, it is made perfectly round. The plumbago is fed into the ruby by being laid on a groove in a piece of metal, with a steel pin to keep the plumbago from being pressed back.

The pure Cumberland black-lead (plumbago) is of too soft and yielding a nature to enable an artist to make a fine clear line; to produce, therefore, a pencil that will effect this, a hard resinous matter is intimately combined with the lead in the following way:—Fine Cumberland lead (in powder) and shellac are first melted together by a gentle heat; this compound is then reduced to powder again, then remelted, then powdered again, and remelted until both substances are perfectly incorporated, and it has acquired a perfectly uniform consistence. The mass is then sawed into slips, and glued into the cedar mountings, in the usual manner of making other black-lead pencils. To render them of various degrees of hardness, the materials are differently proportioned; the hardest having the most shellac, the softer but very little, and the softest none; and their blackness is increased in proportion to their softness.

PENDANT. In Gothic architecture, an ornamented polygonal piece of stone or timber hanging down from the vault or roof of a building. Of stone pendants some exquisite examples may be seen in Henry VIII.'s Chapel at Westminster. In ancient writers the springers of arches, which rest on shafts or corbels, are called *pendants.*

Pendants of a Ship are those streamers or long colors which are split or divided into two parts ending in points, and hang at the mast-head or at the yard-arm ends.

Pendant. In painting, a picture or print which, from uniformity of size and subject, seems to hang up as a companion to another. The term may also be applied to bassi relievi of similar sizes.

Pendant is also the general term for all kinds of ornaments worn in the ears by both sexes in savage, and by females, chiefly, in civilized, countries; usually termed ear-rings, which see.

PENS. Well known instruments for writing, usually formed of the quills of the goose, swan, or some other bird. Metallic pens have been occasionally employed for a lengthened period; but it is only within these few years that they have been extensively introduced. They first began to be largely manufactured by Mr. Perry, of London. Mr. P. having succeeded in giving to his pens a greater degree of softness and elasticity than was possessed by any metallic pens previously in use, they speedily obtained a very extensive sale. This success brought crowds of rivals into the field; so that metallic pens are now manufactured in vast quantities.

Pens, Steel. The best metal, made from Dannemora or hoop (L) iron, is selected, and laminated into slips about 3 feet long, and 4 inches broad, of a thickness corresponding to the desired stiffness and flexibility of the pens. These slips are subjected to the action of a stamping-press, somewhat similar to that for making buttons. (*See* BUTTON, and PLATED WARE.) The point destined for the nib is next introduced into an appropriate gauged hole of a little machine, and pressed into the semi-cylindrical shape; where it is also pierced with the middle slit, and the lateral ones, provided the latter are to be given. The pens are now cleaned, by being tossed about among each other, in a tin cylinder, about 3 feet long, and 9 inches in diameter; which is suspended at each end upon joints, to two cranks, formed one on each of two shafts. The cylinder, by the rotation of a fly-wheel, acting upon the crank-shafts, is made to describe such revolutions as agitate the pens in all directions, and polish them by mutual attrition. In the course of 4 hours several thousand pens may be finished upon this machine.

Hardness in the nib being the desirable quality, and the loss of time mending quill pens being seriously felt, substitutes have been generally adoped. Such as silver and gold pens, tortoise-shell barrels and ruby or diamond nibs have been made. Pens of ruby, set in fine gold, have been said to last 6 years. Some gold pens have the nibs made of rhodium. Some gold pens, on examination at the Laboratory, Cambridge, Mass., have turned out to be sheet-iron, galvanized and plated. The iron is first cut out with the press, thin coated with zinc, and finally with gold.

Fountain pens are made to hold a reservoir of ink. Music pens make dots as well as strokes. The geometric pen is an ingenious instrument for drawing curves.

American gold pens. Dr. Spargen, to whom the public is already indebted for several ingenious inventions, has now patented a new pen, which promises to have important advantages without being in any degree costly. These are the retention of a large quantity of ink, sufficient, for example, to write a letter without again dipping the pen, and the prevention of corrosion. Capilary attraction and galvanism are the principles involved, and the means employed are very simple. Within a common iron pen a small plate of zinc, bent to follow the line of the pen, is secured by points of solder at a short distance from the former, by means of which the ink is securely retained, and a galvanic current is kept up. The progress of the manufacture of *gold* pens in America will serve to show the extent of business which may be done in an article of this kind, when successful.

The *Charleston Courier* (U. S.) says, the first gold pen was made in New-York in 1838, and now the principal manufacturer of them employs a capital of 80,000 dollars in the undertaking. In the manufacture of pens the gold is first rolled out in ribbons, and then cut with a die to the proper shape, the points put on and then ground down to the required nib. The points are of iridium, a new metal found with platinum. The points are all imported, generally without the ceremony of an introduction to the Custom House, and cost from 7 to 55 dollars per ounce. The pens and cases sell from 10 to 80 dollars per dozen. It is not easy to make an estimate of the number of pens manufactured per annum, but it is probably not less than 1,000,000, of which one manufacturer, Bagley, makes nearly half. A person who had not thought of the subject would scarcely suppose that 800 lbs. of gold were used up every year in America, in the manufacture of such a trifling article as pens—a business unknown ten years ago—yet such is the fact. A statement of the tons of iron worked into pens in England every year would be even more startling, and would show that Dr. Spurgen's improvement, simple as it appears, may, if it fulfils its promises, be more productive than some larger matters.

PENDULUM. If any heavy body, suspended by an inflexible rod from a fixed point, be drawn aside from the vertical position, and then let fall, it will descend in the arc of a circle of which the point of suspension is the centre. On reaching the vertical position it will have acquired a velocity equal to that which it would have acquired by falling vertically through the versed sine of the arc it has described, in consequence of which it will continue to move in the same arc until the whole velocity is destroyed; and, if no other force than gravity acted, this would take place when the body reached a height on the opposite side of the vertical equal to the height from which it fell. Having reached this height it would again descend, and so continue to vibrate for ever; but in consequence of the friction of the axis, and the resistance of the air, each successive excursion will be diminished and the body soon be brought to rest in the vertical position. A body thus suspended, and caused to vibrate, is called a *pendulum;* and the passage from the greatest distance from the vertical on the one side to the greatest distance on the other is called an oscillation.

In order to investigate the circumstances of the motion, the body must be regarded as a gravitating point, and the inflexible rod as devoid of weight. This is denominated the *simple pendulum*, and the problem to be resolved is to determine the motion of a point constrained to move in a circular arc in virtue of the accelerating force of terrestrial gravity.

According to the theory of falling bodies (see GRAVITY,) the time t in which a body falls through the space s, by the

the accelerating force of gravity, is given by the equation $t=\sqrt{\frac{2}{g}}$. Let $2s=l$; then $t=\sqrt{\frac{l}{g}}$. But the time T, of the oscillation of a pendulum whose length is l, is $T=\pi\sqrt{\frac{l}{g}}$; therefore $T:t::\pi:1$; consequently the time of the oscillation of a pendulum is to the time that a heavy body would fall freely by the force of gravity through half its length, as the circumference of a circle to its diameter.

If we suppose that the time to be expressed in seconds, and make $T=1$, we shall have $g=\pi^2 l$. Now, Captain Kater found the length of the same pendulum at London to be 39·13929 inches, and we know that $\pi^2=9{\cdot}8696$; therefore $g=9{\cdot}8696\times 39{\cdot}139=386{\cdot}239$ inches, or $g=32{\cdot}2$ feet. It follows, therefore, that the space through which a body falls freely at London in a second time is 16·1 feet.

Compound Pendulum. The simple pendulum, as above defined, is only a theoretical abstraction; for the oscillating body can neither be so small that it may be regarded as a mathematical point, nor can the rod be entirely devoid of weight. When the body has a sensible magnitude, and the suspending-rod a sensible magnitude and weight as they must have in all actual constructions, the apparatus is called a *compound pendulum*; and instead of being supported by a single point it is supported by an axis, or by a series of points situated in the same straight line. According to this definition, any heavy body oscillating about an axis of suspension is a compound pendulum.

In every compound pendulum there is necessarily a certain point at which if all the matter of the pendulum were collected the oscillations would be performed in exactly the same time. This point is the centre of oscillation. (*See* CENTRE OF OSCILLATION.) It is situated in the vertical plane passing through the centre of gravity of the pendulum, and at a distance from the axis of suspension (the axis being always supported horizontal,) which is determined by the following formula: Let $d\,m$ be the element of the mass of the compound pendulum, r its distance from the axis of rotation, and x the distance of the centre of oscillation from the same axis; then

$$x=\int r^2\,d\,m\div\int r\,d\,m\,;$$

that is, the distance of the centre of oscillation from the axis of suspension is equal to the moment of inertia of the oscillating body divided by its moment of rotation. This value of x is the length of the isochronous simple pendulum, and is what is always to be understood by the term *length of a pendulum.*

The centre of oscillation possesses a very remarkable property, which was discovered by Huygens; namely, that if the body be suspended from this point, or a horizontal axis passing through it parallel to the former axis of suspension, its oscillations will be performed in the same time as before; in other words, the axis of suspension and oscillation are interchangeable. This property furnishes an easy practical method of determining the centre of oscillation, and thence the length of a compound pendulum.

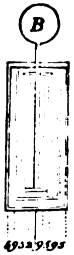
Applications of the Pendulum.—The most important application that has been made of the pendulum is to the measurement of time. It is said that Galileo, while a young man, having had his attention drawn to the oscillation of a lamp suspended from the roof of a church in Pisa, perceived that, although their extent was gradually diminished, they continued to be made in equal times, and thence conceived the idea of employing a pendulum as a means of measuring small intervals of time in astronomical observations. But though a pendulous body, by the isochronism of its oscillations, furnishes a means of dividing time into equal portions, it could obviously be of no great use until a method was devised of continuing the motion, and registering the number of oscillations. The application of clock-work to this purpose has been claimed for various individuals, but is generally and deservedly ascribed to Huygens; and the invention one of the most important that ever was made in reference to practical astronomy, dates from the year 1656.

Huygens' researches on the subject of the oscillations of the pendulum are contained in his admirable work entitled *Horologium Oscillatorium.* He soon found that the oscillations in circular arcs of different amplitudes are not equal, the wider requiring rather a longer time than the narrower; and, with a view to remedy this defect, he undertook to investigate the nature of the curve in which the oscillations would be performed in equal times, whatever might be the extent of the arc described. The curve possessing this remarkable property was found to be the cycloid.

In clocks of the best construction the arc of vibration is very small; and the pendulum is made very heavy, in order that, by possessing a great momentum, it may be less affected by the imperfections of the machinery.

Compensation Pendulum.—The value of the pendulum as a regulator of time-pieces depends on the isochronism of its oscillations; which, in its turn, depends on the invariability of the distance between the points of suspension and oscillation. But, as every known substance expands with heat and contracts with cold, the length of the pendulum will vary with every alteration of temperature, and the rate of the clock consequently undergo a corresponding change. To counteract this variation, numerous contrivances have been employed. The principle is, however, the same in all; and consists in combining two substances, whose rates of expansion are unequal, in such a manner that the expansion of the one counteracts that of the other, and keeps the centre of oscillation of the compound body always at the same distance from the axis of suspension. A brief description of the two compensation pendulums in most common use—the *Mercurial Pendulum* and the *Gridiron Pendulum*—will sufficiently explain the means by which compensation is obtained.

Mercurial Pendulum.—This was the invention of Mr. George Graham, a celebrated watchmaker, who subjected it to the test of experiment in the year 1721. The rod of the pendulum is made of steel, and may be either a flat bar or a cylinder. The bob or weight is formed by a cylindrical glass vessel, about 8 inches in length and 2 inches in diameter, which is filled with mercury to the depth of about 6½ inches. The cylinder is supported and embraced by a stirrup, formed also of steel, through the the top of which the lower extremity of the rod passes, and to which it is firmly fixed by a nut and screw on the end of the rod. Now the effect of an increase of temperature on this apparatus is evidently as follows: In the first place, the rod expands, and the distance between the axis of suspension and the bottom of the stirrup is increased. In the second place, by the expansion of the mercury in the cylinder, its column is lengthened, and the distance of its centre of gravity from the bottom of the stirrup consequently increased. But, as the expansion of mercury is about sixteen times greater than that of steel, the height of the mercurial column may be so adjusted by trial that the expansion of the rod and stirrup shall be exactly compensated by that of the mercury, and the centre of oscillation of the whole suffer no change. This pendulum is, perhaps, the most perfect of all compensators; but, as its adjustments are attended with considerable difficulty, it is seldem used excepting in astronomical observatories.



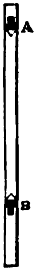
Gridiron Pendulum.—This was contrived by Mr. Harrison, the inventor of the chronometer. It consists of a frame of nine parallel bars of steel and brass, arranged and connected as in the annexed figure. The bars marked *s* are of steel; the four marked *b* are of brass; the centre rod, of steel, is fixed at top to the cross bar connecting the two middle brass rods, but slides freely through the two lower bars, and bears the bob B. The remaining rods are fastened to the cross pieces at both ends, and the uppermost cross piece is attached to the axis of suspension. It is as easy to see, from the mere inspection of the figure, that the expansion of the steel rods tends to lengthen the pendulum, while that of the brass rods tends to shorten it; consequently, if the two expansions exactly counteract each other, the length of the pendulum will remain unchanged. The relative lengths of the brass and steel bars are determined by the expansions of the two metals, which are found by experiment to be, in general, nearly as 100 to 61. If, then, the lengths of all the five steel bars added together be 100 inches, the sum of the lengths of the four brass bars ought to be 61 inches. When the compensation is found on trial not to be perfect, an adjustment is made by shifting one or more of the cross pieces higher on the bars.

Harrison's pendulum has been greatly improved by Troughton, who substituted for the two parallel brass rods two cylinders of brass, sliding the one within the other, to which the steel rods are attached. For a description of this, and various other modes of compensation, we refer the reader to an excellent chapter on the subject by the late Captain Kater, in the volume of *Mechanics* in the *Cabinet Cyclopædia.*

Application of the Pendulum to the Determination of the relative Force of Gravity at different Places.—There are two methods of determining the relative intensity of gravity by means of the pendulum. According to the first, the absolute length of the simple pendulum which makes a certain number of oscillations in a given time is accurately ascertained at each of the places, and the comparative force of gravity is then given by the formula $g' = \frac{l'}{l} g$. According to the other method, an invariable pendulum is swung at the different places, and the number of its oscillations noted at each, when the relative gravity is given by the formula $g' = \frac{N'^2}{N^2} g$. Each of these methods have been followed in the delicate experiments which have been made for the purpose of determining the figure of the earth; but though the results of both appear to be nearly equal in point of accuracy, the latter method, on account of its affording greater facilities in practice, is now generally adopted.

It will readily be conceived that a pendulum would be altogether unfit for the purpose of determining the minute variations of gravity if it were attached to a clock, or any machinery by which its motions could be influenced. It must be suspended from a very firm support, to which it can communicate no vibratory motion; and the most delicate precautions are necessary to avoid the effects of friction, and other disturbing causes, by which the experiment may be influenced. The method followed by the French astronomers, in their operations connected with the measurement of the meridian, was this: The pendulum was composed of a sphere of platinum, suspended by a slender iron wire from a knife edge of hardened steel resting on plane surfaces of polished agate. It was placed in front of a well-regulated astronomical clock, with which its oscillations were compared, and the distance between its centres of suspension and oscillation determined by calculation from the length of the wire and the diameter of the sphere, ascertained by actual measurement. A different, and in many respects preferable mode of measuring the lengths of the seconds' pendulum, was adopted by Captain Kater, grounded on the property of oscillating bodies discovered by Huygens; namely that the centres of suspension and oscillation are convertible. From this property it follows that if two knife edges, turned in opposite directions, are inserted in the same pendulum, and the mass be so adjusted, by means of a movable weight sliding on the rod, that the oscillations are performed in exactly equal times when the pendulum is suspended from either knife edge, then the distance between the knife edges is the true length of the isochronous simple pendulum. In this manner the measurement is effected more directly, and no calculation is required for finding the centre of oscillation. A third method, lately put in practice by the celebrated astronomer Bessel, consists in suspending a ball and wire from the upper end and then from the lower end of a rod of a given length, the ball being in both cases at the same distance below the rod. From the difference of the times of oscillation of the two pendulums thus formed, the length of the simple pendulum can be computed in terms of the rod, which is the difference of their lengths. The French method is described, with all the requisite details, in the third volume of *Base Metrique*, in *Delambre's Astronomie*, tome iii.; and in the *Recueil d'Observations Geodesiques*, *&c.*, by Biot and Arago, Paris, 1821.

Captain Kater's pendulum was formed of a very thin bar of plate brass, with a heavy bob and movable weight, by means of which the isochronism was obtained when the suspension was made from the opposite knife edges. But a much simpler modification has been adopted in the recent experiments. The experimental pendulums of the Royal Astronomical Society consist merely of a plain straight bar of iron or copper, 2 inches wide, half an inch thick, and about 62¼ inches long. At the distance of 5 inches from one end of the bar is placed the apex of one of the knife edges, A; and at the distance of 39·4 inches therefrom the apex of the other knife edge, B; and the required adjustment to synchronism is produced by filling away one of the ends of the pendulum until the vibrations are found by trial to be equal in both positions of the pendulum. It is obvious that, for the purpose of merely ascertaining the variations of gravity, a bar of this form with a single knife edge would equally answer the purpose: but the advantage of the double suspension



is this, that besides having two distinct and independent pendulums, each of which is a check upon the other, it furnishes the means of ascertaining whether the pendulum has sustained any accidental injury, which would be immediately discoverable from the inequality of the number of vibrations between the two knife edges.

Corrections.—In order that the results of different sets of experiments may be exactly comparable with each other, several corrections must be applied. The first of these is on account of the length of the arc of vibration, which, being of a finite and variable extent, the duration of the oscillations is consequently unequal, but always greater than in the case of an infinitely small arc. The number of oscillations is reduced to the case of an infinitely small arc by the formula.

$$N \times \frac{M \sin.(A + a) \sin(A - a)}{32\,(\log. \sin. A - \log. \sin. a)}$$

where N is the number observed, M the logarithmic modulus = ·4342945, A the initial, and a the final arc of vibration; and as the arcs are always small, the computation may be shortened by using the arcs instead of sines.

In the second place, all the experiments must be reduced to a common standard of temperature, which, in this country, is assumed at 62° of Fahrenheit. Let e denote the rate of expansion of the metal, t the mean height of the thermometer at the time of the experiment; then the correction of the number of vibrations on account of the temperature is $N \times \frac{1}{2} e (t - 62°.)$

A third correction is required on account of the atmospheric pressure. The effect of the pressure of the atmosphere on the pendulum is to diminish the force of gravity in the ratio of the specific gravity of the pendulum to that of the air; and on this principle the correction was formerly applied, regard being had to the height of the barometer. But it was recently remarked by Bessel that the pendulum drags with it a certain portion of air, the amount of which depends on the form of the pendulum: and, consequently, the specific gravity of the actually moving mass cannot be previously computed, but must be ascertained for each pendulum by actual experiments in air and in a vacuum.

PEPPER. A condiment obtained from the *piper nigrum*, a native of Malabar, where it is cultivated on an extensive scale. It is a climbing plant, and is supported on a pole, or small tree, planted for this purpose, which gives to the pepper-grounds an appearance similar to hop-fields. The pepper of Malacca, Java, and especially of Sumatra, is the most esteemed. Its culture has been introduced into the Isle of France, and thence into Cayenne and the West Indies.

White pepper is nothing more than the best and soundest of the berries, gathered when fully ripe, and deprived of their external skin, by steeping them in salt-water for about a week, at the end of which time the skins burst; they are then dried in the sun, rubbed between the hands, and winnowed to separate the hulls; it is much less pungent than the entire berries. The leaves of the *P. betel*, a native of the same parts of the globe, serve to enclose a few slices of the areca-nut, called betel-nut, and a little shell lime, which substances together form a masticatory as much in use among these nations as is tobacco in Europe and America.

Black Pepper is composed, according to M. Pelletier, of the vegetable principle, *piperine*, of a very acrid concrete oil, a volatile balsamic oil, a colored gummy matter, an extractive principle analagous to legumine, malic and tartaric acids, starch, bassorine, ligneous matter, with earthy and alkaline salts in small quantity. Cubebs pepper has nearly the same composition.

PEPPERMINT CORDIAL. Into 1 ounce of refined sugar drop 75 drops of oil of peppermint, and, while grinding with the sugar, add to the quantity of 1 pint of alcohol, which liquid mix with 10 pints of alcohol, and 10 gallons of water. Add ¼ oz. of alum, to fine.

Peppermint Drops. Similarly mix and treat 2 lbs. of sugar and 4 oz. of peppermint-water: and, if needful, add a few drops of oil of peppermint.

Peppermint Lozenges. In mucilage of gum dragon, flavored with oil of peppermint about 2 drs. mix 2 lbs. of sugar and 2 oz. of starch.

PERAMBULATOR is an instrument for measuring distances on roads. It consists principally of a wheel, upon which it runs, and an index which shows the number of turns of the wheel reduced into miles, furlongs, poles, or yards. The carriage or stock, which is divided in order to receive the wheel, is made of wood, and is about three feet long. At one end is a handle for the person who uses it, and the other is furnished with sockets, in which the axle of the wheel turns. Upon the stock, and just in front of the handle, is the dial-plate, with its two hands, by which the distance is registered. The wheel is 8¼ feet, or ½ pole in circumference; and upon one end of its axis is a small pinion which works into a similar pinion at the end of a rod passing up the stock or carriage to the works beneath the dial-plate. Motion is communicated by means of this rod to a worm or micrometer screw, which turns once round for each revolution of the carriage-wheel of the perambulator. This worm works into a wheel of 80 teeth, which is moved forward one tooth for every ½ pole, and carries a hand or index, which makes one revolution for 40 poles or one furlong. On the axis of this wheel is a pinion of 8 teeth, which moves a wheel of 160 teeth. This last wheel carries another hand, which makes one revolution for 80 of the former, that is, for ten miles. The movements of the two index hands thus show the miles and furlongs passed over.

There are other instruments for the same or similar purposes, bearing different names, as *Waywiser* and *Odometer*, but the construction of all of them is very similar. Waywiser is the name generally given to that form of the instrument which is applied to a carriage in which, by a slight adaptation to one of the wheels of the carriage, the instrument is made to register the number of turns of such wheel in the same manner as the perambulator.

PERCH. The main timber of a carriage, which extends through the hind and fore spring transom, or bars, by which the principal part of the upper carriage is supported. The hind part is supported and united to it by hooping two extending timbers, called wings, on the side. The fore part is fixed to the perch by a strong piece, hooped at the top, and framed through the fore transom. Some carriages have a horizontal wheel in the front, the same as the crane-neck carriages, and these have no hooping-piece to the perch, but are secured by side-plates. Those on the general principle have, at the bottom in front, a flat piece called a tongue, which goes through a large mortice in the fore axle-tree bed, and through which the perch bolt passes.

Sometimes the perch is bent, called a compass perch, for the purpose of admitting the body to hang low, or to form a more agreeable line to the shape. When the carriage is intended for a whole or horizontal wheel, the perch has no hooping-piece, but is bolted by the plates at each end to the inside of the transoms. Plating the sides with iron is a great improvement, and always must be done to perches required to be light in appearance.

PERCUSSION CAPS. *See* FULMINATING MERCURY.

PERCUSSION LOCKS have no pan. In the place of the pan, a small tube projects horizontally from the side of the gun, and in this tube another small tube stands perpendicularly. The cock, instead of being formed to hold a flint, is shaped somewhat like a hammer, with a hollow to fit upon the last tube. On this tube a little cap of copper is placed, in the bottom of which is a chemical mixture that kindles by percussion. This percussion is produced by the cock, which therefore requires a very strong spring.

The powder is made of different materials; among others, of mercury, purified nitric acid, and spirit of wine freed from water. The copper-caps in which this powder is placed are two and a half lines long and two lines wide. Sometimes the powder is also formed in pills, and then a somewhat different contrivance is required to place the pills, covered with a little wax, to protect them from moisture, in the small tube.

PERFORATING GLASS, EARTHENWARE, &c. The only tools requisite for this are a few worn out three-edged hand-saw files. These being generally made of cast steel, retain when ground a very fine point, which is of the utmost importance. In order, however, to give them the requisite degree of hardness, it is necessary to make their ends, for about an inch, red hot, and then plunge them into cold water. By this treatment they become hard and brittle; care is, therefore, required in grinding them to a proper point, which is easily effected on a common grind-stone. There generally is given to them a few rubs on a fine oil-stone after the grinding, so as to produce a very fine point. A cylindrical piece of any sort of wood, about two inches long, terminated by a half-round end, having a hole about the tenth of an inch in diameter, through its axis, may either be fastened into a common bench vice, or on a table. This constitutes the only support required. Suppose that a glass to cover the face of a wheel barometer is wanted, through which it is sometimes necessary to make a perforation for the purpose of passing the screw of the nonious through; a proper piece of glass being selected, is to be marked with a dot of ink on the place where the intended perforation is to be made; the glass is then to be held horizontally by the left hand, and immediately over the hole in the wood support above mentioned. A three-edged file having been hardened and ground to a fine point in the manner above described, is held firmly between the fore-finger and thumb of the right hand, precisely in the position that a pen or pencil is retained when writing. The pointed steel is then to be repeatedly impinged against the glass over the spot intended to be perforated, taking care not to use too much violence. In a short time the outer surface is removed, and, by a continuation of the process, a conical piece is forced from the under surface of the glass through a hole in the wood support; the perforation so produced never exceeds in size a pin's head, but may be made as large as required by holding it over the hole in the support, and working round its edge with a fine pointed file. In this way, after a little practice, and in a very few minutes may be perforated, with ease, all descriptions of glass, from the thinnest crown to the thickest plate, without any danger.

Wine-glasses or tumblers may, also, be easily perforated in a similar manner; but there is mostly employed another process for them. These being made of a softer sort of glass, require only to be moved by the hand backwards and forwards, in the manner of drilling, on the sharp point of the file, with the occasional assistance of a little oil and emery. Indeed any sort of glass may be perforated in this manner, but not so quickly as by the method of punching. All the varieties of china and earthenware may be perforated by either of the above processes with certainty.

PERFUMERY.—Dr. Ure in his Dictionary of the Arts, gives the following directions for obtaining and preparing the most important essences, &c., which are slightly condensed. The essential oils or essences obtained in the south of France are those of roses, neroli, petit-grain, lavender, wild-thyme, thyme, and rosemary. These essences are distilled in the usual manner. They obtain, by putting into the body of the still 40 lbs. of rose leaves, and 30 pints of water, and proceeding to distillation, 15 pints of rose water. They then continue the operation until they have obtained 200 pints of water, termed No. 1. In this first distillation, they obtain an almost imperceptible quantity of the *essence of roses*; but in the second it becomes more apparent; and, finally, in the fifth it becomes notable.

In the distillation of *orange-flowers*, they also obtain the *essence of neroli*, now become of remarkable importance. If they would obtain this essence they follow the ordinary process, and repass the waters of the first distillations upon new flowers. On the contrary, when it is intended to prepare orange-flower water of a good quality, they draw off a fifth part only of the water placed in the cucurbit.

Of pommades by infusion.—Rose, orange-flower, and cassia. Take 334 pounds of hog's lard, and 166 of beef suet. These 500 pounds are put into a pan called *bugadier*; and when melted, 150 pounds of rose-leaves nicely plucked are added, taking care to stir the mixture every hour. The infusion thus prepared is to remain at rest for 24 hours; at the end of this time, the pommade is again melted, and well stirred to prevent its adherence to the bottom of the melting-pan. The mass is now to be poured out into canvas, and made into rectangular bricks or loaves, which are subjected to a press, in order to separate the solid matter from the soft pommade. These brick-shaped pieces being put into an iron-bound barrel perforated all over its staves, the pommade is to be allowed to exude on all sides, and flow down into a copper vessel placed under the trough of the press. This manipulation should be repeated with the same fat ten or twelve times; or in other words, 3000 pounds of fresh rose-leaves should be employed to make a good pommade.

The pommade of orange-flowers is made in the same manner, as also the pommade of cassia.

Of pommades without infusion.—Jasmine, tuberose, jonquil, narcissus, and violet.

A square frame, called *tiame*, is made of four pieces of wood, well joined together, 2 or 3 inches deep, into which a pane of glass is laid, resting upon inside ledges near the bottom. Upon the surface of the pane the simple pommade of hog's lard and suet is spread with a pallet knife; and into this pommade the sweet scented flowers are stuck fresh in different points each successive day, during two or three months, till the pommade has acquired the desired richness of perfume.

Of Oils.—Rose, orange-flower, and cassia oils, are made by infusion, like the pommades of the same perfumes ; taking care to select oils perfectly fresh. As to those of jasmine, tuberose, jonquil, violet, and generally all delicate flowers, they are made in the following manner. Upon an iron frame, a piece of cotton cloth is stretched, imbued with olive oil of the first quality, and covered completely with a thin bed of flowers. Another frame is similarly treated, and in this way a pile is made. The flowers must be renewed till the oil is saturated with their odor. The pieces of cotton cloth are then carefully pressed to extrude the oil. This last operation requires commonly 7 or 8 days.

Essence of Roses.—Put into the body of a still 40 pounds of roses, and 60 quarts of water ; distil off one half of the water. When a considerable quantity of such water of the first distillation is obtained, it must be used as water upon fresh rose-leaves ; a process of repetition to be carried to the fifth time. In the distillation of orange-flower, to obtain the essence of neroli, the same process is to be followed ; but if orange-flower water merely be wanted, then it is obtained at one distillation, by reserving the first fifth part of water that comes over. What is called the essence of *petit-grain*, is obtained by distilling the leaves of the orange shrub.

Of scented spirits, from oil of rose, orange, jasmine, tuberose, cassia, violet, and other flowers.

Into each of three digesters, immersed in water-baths, put 25 lbs. of any one of these oils, and pour into the first digester 25 quarts of spirits of wine ; agitate every quarter of an hour during three days, and at the end of this period, draw off the perfumed spirit, and pour it into the second digester ; then transfer it after 8 days into the third digester, treating the mixture in the same way ; and the spirit thus obtained will be perfect. The digesters must be carefully covered during the progress of these operations. On pursuing the same process with the same oil and fresh alcohol, essences of inferior qualities may be obtained, called Nos. 2, 3, and 4.

Esprit de Saure.

7	Eng. qrts. of spirits of	jasmine, 3d	operation.
7	do.	cassia,	do.
8	do.	wine.	
2	do.	tuberose,	do.
1½	ounces of essence of cloves.		
½	ounce fine neroli.		
1½	ounce essence of bergamot.		
8	ounces of essence of musk, 2d infusion.		
3	quarts of rose water.		

Spirit of Cytherea.

1	quart spirit of	violets.
1	do.	jasmine, 2d operation.
1	do.	tuberose, do.
1	do.	clove gillyflower.
1	do.	roses, 2d operation.
1	do.	Portugal.
2	do.	orange-flower water.

Spirit of Flowers of Italy.

2	quarts of spirit of	jasmine, 2d	operation.
2	do	roses,	do.
2	do.	orange, 3d	do.
2	do.	cassia, 2d	do.
1½	do.	orange-flower water.	

The above spirits mark usually 28 alcometric degrees of Gay Lussac. (*See* ALCOHOL.)

Pommade.—No less than 20 scented pommades are distinguished by the perfumers of Paris. The essences commonly employed in the manufacture of pommades, are those of bergamot, lemons, *cedrat*, *limette* (sweet lemon), Portugal, rosemary, thyme, lemon thyme, lavender, marjoram, and cinnamon.

The following may serve as an example :—

Pommade à la Vanille, commonly called Roman.

12	pounds of	pommade à la rose.
3	do.	oil à la rose.
1	do.	vanilla, first quality, pulverized.
6	ounces	bergamot.

The pommade being placed at the heat of a water-bath, the vanilla is to be introduced with continual stirring for an hour. The mixture is left to settle during two hours. The pommade is then to be drawn off, and will be found to have a fine yellow color, instead of the brown shade which it commonly has.

In making odoriferous extracts and waters, the spirits of the flowers prepared by macerating the flowers in alcohol should be preferred to their distillation, as forming the foundation of good perfumery. The specific gravity of these spirits should be always under 0·88.

Extract of Nosegay (Bouquet).

2	quarts	spirit of jasmine, 1st	operation.
2	do.	extract of violets,	
1	do.	spirit of cassia, 1st	do.
1	do.	roses, do. 1st	do.
1	do.	orange, do. 1st	do.
1	do.	extract of clove gillyflower.	
4	drms. of flowers of benzoin (benzoic acid).		
8	ounces of essence of amber, 1st infusion.		

Extract of Peach Blossoms.

6 quarts of spirits of wine.
6 pounds of bitter almonds.
2 quarts of spirits of orange-flower, 2d operation.
4 drachms of essence of bitter almonds.
4 drachms of balsam of Peru.
4 ounces of essence of lemons.

Eau de Cologne.—Two processes have been adopted for the preparation of this perfume, distillation and infusion; the first of which, though generally abandoned, is, however, the preferable one. The only essences which should be employed, and which have given such celebrity to this water, are the following: bergamot, lemon, rosemary, Portugal, neroli. The whole of them ought to be of the best quality, but their proportions may be varied according to the taste of the consumers.

Thirty different odors are enumerated by perfumers: the following recipes will form a sufficient specimen of their combinations.

Honey Water.

6 quarts of spirits of roses, 3d operation.
3 do. jasmine.
8 do. spirits of wine.
8 ounces essence of Portugal.
4 drachms of flowers of benzoin.
12 ounces of essence of vanilla, 3d infusion.
12 do. musk, do.
8 quarts good orange-flower water.

Eau de Mille Fleurs.

18 quarts of spirits of wine.
4 ounces balsam of Peru.
8 do. essence of bergamot.
4 do. cloves.
1 do. ordinary neroli.
1 do. thyme.
8 do. musk, 3d infusion.
4 quarts orange-flower water.

Eau de Mousseline.

2 quarts spirit of roses, 3d infusion.
2 do. jasmine, 4th do.
1 do. clove gillyflower.
2 do. orange-flower, 4th infusion.
2 ounces essence of vanilla, 3d do.
1 do. musk, do.
2 drachms of sanders wood.
1 quart of orange-flower water.

Almond Pastes.—These are, gray, sweet white, and bitter white.

The first is made either with the kernels of apricots, or with bitter almonds. They are winnowed, ground, and formed into loaves of 5 or 6 pounds weight, which are put into the press in order to extract their oil; 300 pounds of almonds affording about 130 of oil. The pressure is increased upon them every two hours during three days; at the end of which time the loaves or cakes are taken out of the press to be dried, ground, and sifted.

PERSIAN WHEEL. In mechanics, a contrivance for raising water to some height above the level of a stream. In the rim of a wheel turned by the stream a number of strong pins are fixed, from which buckets are suspended. As the wheel turns, the buckets on one side go down into the stream, where they are filled, and return up full on the other side till they reach the top. Here an obstacle is placed in such a position that the buckets successively strike against it and are overset, and the water emptied into a trough. As the water can never be raised by this means higher than the diameter of the wheel, it is obvious that this rude machine is capable of only a very limited application. Sometimes the wheel is made to raise the water only to the height of the axis. In this case, instead of buckets, the spokes are made hollow, and bent into such a form that when they dip into the water it runs into them, and is thus conveyed to a box on the axle, whence it is emptied into a cistern. Such wheels are in common use on the banks of the Nile, and elsewhere.

PETALITE. A Swedish mineral of a gray or reddish color and a foliated texture. It is a silicate of alumina and lithia, and contains between five and six per cent. of the latter alkali.

PETROLEUM. A brown liquid bitumen, found in several parts of Europe, in Persia, and in the West Indies. It is often termed *Barbadoes tar.*

PETROLINE. A substance obtained by distilling the petroleum of Rangoon; analogous to *paraffine.*

PETROSILEX. A variety of flint or hornstone. The term is sometimes applied to compact feldspar.

PETUNTZE. A decomposing variety of feldspar, used in China in the manufacture of porcelain.

PEWTER, PEWTERER. Pewter is, generally speaking, an alloy of tin and lead, sometimes with a little antimony or copper, combined in several different proportions, according to the purposes which the metal is to serve. Plate pewter has a bright silvery lustre when polished; the best is composed of 100 parts of tin, 8 parts of antimony, 2 parts of bismuth, and 2 of copper. The trifle is said by some to consist of 83 of tin, and 17 of antimony; but it generally contains a good deal of lead. The ley pewter is composed of 4 of tin, and 1 of lead. As the tendency of the covetous pewterer is always to put in as much of the cheap metal as is compatible with the appearance of his metal in the market, and as an excess of lead may cause it to act poisonously upon all vinegars and many wines, the French government long ago appointed Fourcroy, Vauquelin, and other chemists, to ascertain by experiment the proper proportions of a safe pewter alloy. These commissioners found that 18 parts of lead might, without danger of affecting wines, &c., be alloyed with 82 parts of tin; and the French government in consequence passed a law requiring pewterers to use 83½ of tin in 100 parts, with a tolerance of error amounting to 1½ per cent. This ordonnance, allowing not more than 18 per cent. of lead at a maximum, has been extended to all vessels destined to contain alimentary substances. A table of specific gravities was also published, on purpose to test the quality of the alloy; the density of which, at the legal standard, is 7·764. Any excess of lead is immediately indicated by an increase in the specific gravity above that number.

The pewterer fashions almost all his articles by casting them in moulds of brass or bronze, which are made both inside and outside in various pieces, nicely fitted together, and locked in their positions by ears and catches or pins of various kinds. The moulds must be moderately heated before the pewter is poured into them, and their surfaces should be brushed evenly over with pounce powder (sandarach) beaten up with white of egg. Sometimes a film of oil is preferred. The pieces, after being cast, are turned and polished; and if any part needs soldering, it must be done with a fusible alloy of tin, bismuth, and lead.

Britannia metal, the kind of pewter of which English tea-pots are made, is said to be an alloy of equal parts of brass, tin, antimony, and bismuth; but the proportions differ in different workshops, and much more tin is commonly introduced. Queen's metal is said to consist of 9 parts of tin, 1 of antimony, 1 of bismuth, and 1 of lead; it serves also for tea-pots and other domestic utensils.

PHANTASCOPE. A curious instrument invented by Prof. John Locke, which will illustrate, in a manner never before accomplished, "single vision by each eye." It is very simple, and has neither lenses, prisms, nor reflectors. It consists of a flat board base, about nine by eleven inches, with two upright rods, one at each end, a horizontal strip connecting the upper ends of the uprights, and a screen or diaphragm, nearly as large as the base, interposed between the top strip and the tubular base, this screen being adjustable to any intermediate height. The top strip has a slit one-fourth of an inch wide, and about three inches long from left to right. The observer places his eyes over this slit, looking downward. The movable screen has also a slit of the same length, but about an inch wide. If there are two identical pictures of a flower, about one inch in diameter, placed the one to the left and the other to the right of the centre of the tabular base, or board forming the support, and about two and a half or three inches apart from centre to centre. A flower-pot or vase is painted on the upper screen, at the centre of it as regards right and left, and with its top even with the lower edge of the open slit. By looking downward through the upper slit, and directing both eyes steadily to a mark, a quasi stem, in the flower pot or vase—instantly a flower similar to one of those on the lower screen, but of half the size, will appear growing out of the vase, and in the open slit of the moveable screen. On directing the attention through the upper screen to the base, this phantom flower disappears, and only the two pictures on each side of the place of the phantom remain. The phantom itself consists of the two images painted on the base, optically superimposed on each other. If one of these images be red and the other blue, the phantom will be purple. If two identical figures of persons be placed at the proper positions on the lower screen, and the upper screen be gradually slid up from its lowest point, the eye being directed to the index, each image will at first be doubled, and will gradually recede, there being of course four in view until the two contiguous coincide, when three only are seen. This is the proper point where the middle or double image is the phantom seen in the air. If the screen be raised higher, then the middle images pass by each other, and again four are seen receding more and more as the screen is raised.

As all this is the effect of crossing the axes of the eyes, it follows that a person with only one perfect eye cannot make the experiments. They depend on *binocular vision*.

All these effects depend on the principle that one of the two primitive pictures is seen by one eye, and the other by the other eye, and that the axes are so converged by looking at the index or mark on the upper screen that those separate images fall on the points in the eye, which produce single vision. To a person who has perfect voluntary control over the axes of his eyes, the upper screen and index are unnecessary. Such an observer can at any time look two contiguous persons into one, or superimpose the image of one upon the image of the other.

PHOSGENE GAS. A compound of chlorine and carbonic oxide, made by exposing equal measures of those gases to the sunshine, or to bright daylight. They will not unite in the dark.

PHOSPHATES. Salts containing *phosphoric acid.*

PHOSPHITES. Salts containing *phosphorous acid.*

PHOSPHORESCENCE. The emission of light by substances at common temperatures, or below a red heat.

PHOSPHATE OF SODA is made by dissolving 14 parts of crystallized carbonate of soda in 21 of water, at 150°; to this is to be added, gradually, 5 of phosphoric acid, sp. gr. 1·85, boiling the mixture for a few minutes, filtering it, and letting it crystallize by cooling; from 14 to 15 of phosphate of soda crystallizes.

It is now extensively used in the arts of calico printing and dyeing.

PHOSPHORESCENCE is the property which certain bodies possess, of becoming luminous without undergoing combustion, as, when we rub or heat them, or in consequence of the action of the living principle, or of decomposition. Two pieces of quartz emit light on being rubbed together. Light is seen in breaking lumps of sugar. A variety of blende (sulphuret of zinc), on being scratched with a knife, emits a fine yellow light.

PHOSPHORIC ACID is present in the solid parts of all animals, and displayed especially in the urine. By Barry's experiments, it appeared in all pharmaceutical extracts, and it exists in all articles of food, and, as phosphate of lime, exists in bones, and in all vegetables. It appears in all the substances of animals, and their products. In the mineral kingdom, it is found in lead and iron, in silex, in calcareous earths, and in union with lime, sometimes in whole mountains, as in Spain and Hungary. The acid is formed by the combustion of phosphorus, and, so to speak, is an oxide. But it is also made by distilling phosphorus with nitric acid, or with sulphuric acid or chlorine. It is soluble in water, which takes up 1·687 with increase of temperature. Distilled with charcoal or inflammables, they abstract its oxygen, and it returns to the state of phosphorus.

Phosphoric acid and barytes form a salt, which, with great heat, forms gray enamel.

Phosphoric acid and lime, or phosphate of lime, is insoluble in water till calcined. It absorbs grease, and serves to polish stones and metallic surfaces. (*See* PHOSPHORITE.)

Phosphates of potash and soda are made, and the latter is used, as a purgative salt, having no flavor; also in assays, and in soldering.

Phosphate of ammonia abounds in urine, and much employed as a flux, and in coloring glass.

Other phosphates are formed, but not applied to any purpose.

PHOSPHORUS. So called from its property of shining in the dark. It was discovered in 1668 by Brandt, an alchemist of Hamburgh, and was originally obtained by distilling urine; but it is now always extracted from *bone earth*, by a process contrived by Scheele. The bones are calcined, so as to destroy the animal matter, and, being powdered, are mixed with water, to which half their weight of sulphuric acid is added. The bone earth, consisting chiefly of phosphate of lime, is thus decomposed, sulphate of lime is formed, and phosphoric acid is evolved; or, rather, superphosphate of lime, which, being much more soluble than the sulphate, remains in the liquid, and may be obtained by its evaporation; it is mixed with about half its weight of charcoal, and put into a well-luted earthen retort, the beak of which dips into water. At a bright red heat, the phosphorus distils over into the water. It is purified by carefully melting it under water, and straining it through a piece of chamois leather.

Pure phosphorus is almost colorless, and semi-transparent; it may be cut with a knife, and its surface has a waxy lustre. It fuses at 108°, boils at 550°, and is converted into vapor, having, according to Dumas, a density = 4·35. It is sparingly soluble in fixed and volatile oils, and in ether and alcohol; but insoluble in water. It shines in the dark, and emits a luminous vapor, undergoing a slow combustion, and exhaling a peculiar smell like garlic. When rubbed, or heated to a temperature of about 110°, it takes fire and burns with great rapidity, with a white flame, emitting abundance of acid fumes; in oxygen gas its combustion is so intensely brilliant that the eye can scarcely bear the light.

The product of the perfect combustion of phosphorus is *phosphoric acid*, a fusible substance, very soluble in water, and intensely sour. It appears to consist of 1 equivalent of phosphorus = 16, and 2½ of oxygen = 20; its equivalent being 36.

There are two other acids of phosphorus: namely, the *phosphorous acid*, consisting of 16 phosphorus + 12 oxygen; and the *hypophosphorous acid*, which appears to be a compound of 2 equivalents of phosphorus (16 × 2) = 32, and 1 of oxygen = 8. When phosphorus is boiled in a solution of caustic potash a gas is evolved, which is remarkably distinguished by its spontaneous inflammability; each bubble, as it rises through the water, taking fire upon the surface, and producing a beautiful ring of smoke: this gas is commonly called *phosphuretted hydrogen*. Phosphorus may be made to combine with the greater number of the metals, forming compounds called *phosphurets*.

Wohler recommends, as likely to afford phosphorus at a very cheap rate, to distil by a strong heat ivory black, with half its weight of fine sand and charcoal powder. A silicate of lime is formed, and the carbonic oxide and phosphorus come over.

If phosphorus be put with alcohol into a bottle, and shaken for some time, it may be obtained in powder of the utmost tenuity, which, when diffused through the alcohol, appears as if it consisted of a multitude of minute crystals.

At the temperature of 60° F., or upwards, carbon in the form of animal charcoal, or lamp-black, causes the inflammation of a stick of phosphorus powdered with it, and the effect takes place either in the open air, or in a close receiver of a moderate size.

Phosphorus Bottle.—In a phial, mix, by gentle heat for half an hour, 2 drs. of phosphorus, with 1 dr. of lime. Or, in a phial, with water, melt 1 dr. of phosphorus, and 15 grs. of white wax. On cooling, as the mass grows solid, turn the phial till the inside is coated, when discharge the water, and dry cool.

Canton's Phosphorus is formed by mixing three parts of calcined oyster-shells in powder, with one of flowers of sulphur, and ramming the mixture into a crucible, and igniting it for half an hour. The bright parts will, on exposure to the sunbeam, or to the common daylight, or to an electrical explosion, acquire the property of shining in the dark, so as to illuminate the dial of a watch. It will, after a while, cease to shine; but, if we keep the powder in a well-corked phial, a new exposure to the sun's light will restore the phosphorescent quality.

Temperature has a marked effect on the emission of light by these bodies. When they are shining, the luminous appearance ceases if they are exposed to the cold of a freezing mixture. It becomes more vivid by applying heat; and if it has ceased, it may be renewed by applying a stronger heat, so that a piece of any solar phosphorus, which has apparently lost its power, may by heat be again made to shine, Some of the phosphorescent bodies just mentioned, after their luminousness is over, upon partially heated iron, yield on fusion a very vivid light. Lime is the substance possessing this property in the most remarkable degree. If a piece of calcareous spar is placed on charcoal before the compound blow-pipe, it emits a light so vivid and white that it can scarcely be looked upon.

Phosphorus Match Light.—Into a large flask, heated in a sand-bath, put eight parts of pure phosphorus, which half melt, without allowing it to oxidize. Add four equal parts of magnesia; begin to mix the whole at a heat of 234·5°; reduce the heat gradually to 106·25°, and in about an hour you will have a fatty powder, which is to be put into bottles, and, when cold, carefully stopped. This substance will instantly inflame a common match.

PHOTOGRAPHY, or HELIOGRAPHY. Under the article Daguerreotype, full mention of the action of the salts of silver under the influence of light has been described. Photographic processes require no silver plate, making use of paper or some non-conducting material and applying on its surface sensitive salts of silver, which are to be protected from the light until they are ready to be exposed in the camera.

The term "Photogenic Drawing" has usually been applied to representations of various objects upon paper imbued with some of the salts of silver. If a piece of paper be dipped into a weak solution of nitrate of silver, carefully dried, and preserved out of the contact of light, it remains white; but if exposed to light it gradually becomes discolored, acquiring a brownish or gray tint, and ultimately blackens, the depth of color depending upon the intensity of the light and duration of exposure. If any opaque or translucent object be laid upon a sheet of paper so prepared, so as wholly or partially to intercept the incident light, a representation of the object is obtained upon the paper. Where the light has been wholly intercepted, it remains white; where partially so, various shades are produced; and wherever the light has fallen without interruption, the utmost blackness is obtained. If, for instance, a portrait painted in transparent colors upon a plate of glass be laid upon a piece of the prepared paper, and exposed to the solar light, a copy is obtained in which the lights of the original are shades, and the shades lights in proportion to their intensity; but if such a picture be taken upon a very thin piece of paper, this may be again copied by a repetition of the process, and then the lights and shades will be as in the original. It is, however, obvious that such a photograph will only be durable whilst kept in the dark, and that exposure to light will gradually obliterate the whole; to fix it, the paper must be washed in a solution of hyposulphite of lime or of soda, which removes all remaining and unaltered salt of silver, but leaves the image untouched. In this process the paper, after having been impregnated with nitrate of silver, or with ammonia-nitrate of silver, is generally dipped in a solution of common-salt, by which chloride of silver is formed, and this is more susceptible of the influence of light than the mere nitrate.

Various salts of silver have been used by different operators, and the processes have received different names: those of Mr. Talbot and Sir. J. Herschel are the most approved. The invention was first made public by M. Arago. Mr. Hunt's process called *chromatype* is given under that article, and under the head *calotype* is given Mr. F. Talbot's process.

The *Cyanotype* of Sir J. Herschel is made by washing the paper with a solution of ammonio citrate of iron. It is then exposed to light, and a latent picture impressed on it. If the paper be sensibly darkened, the picture will appear negative. It is now touched over sparingly and equally with a solution of ferro-cyanide of potassium in which is dissolved a little gum. The negative picture vanishes and is replaced by a positive one of a violet blue on a green ground; a second washing brings out the picture clearer.

A second process of the cyanotype is, to saturate the paper with a solution of equal parts of ammonio citrate of iron and ferro sesquicyanide of potassium. When a picture has been impressed it is thrown into water and then dried, and a negative picture results. When this is washed with solution of proto-nitrate of mercury it is discharged, but may be restored by washing out the nitrate and drying the paper. A smooth hot iron is now passed over it, and the obliterated picture comes out of a brown tint; these photographs fade, but are restored by heat.

Third process: 1 pint of ammonio-citrate of iron is dissolved in 11 parts of water, and this is mixed with an equal quantity of a cold, saturated solution, of bichloride of mercury, before the precipitate is formed: the solution is brushed over paper, which should have a tint of yellow. This paper keeps well: when a picture is formed on it, it is washed over with a saturated solution of prussiate of potash, diluted with thin gum water. The picture is fixed by drying, and are beautiful positive ones.

Another process of Herschel's is, to mix solution of nitrate silver of sp. gr. 1·200, with ferro-tartaric acid solution sp. gr. 1·023, till a precipitate falls which is redissolved by heat, leaving a black sediment and a pale yellow liquor. This liquor undergoes no further alteration. This is spread on paper and exposed wet to sunshine for a few seconds, when it may be withdrawn. The image gradually comes out afterwards, and is very intense. If dried before exposure in the camera, an invisible image is formed, which, on breathing upon, immediately appears, and, as if by magic, acquires great sharpness: instead of breathing upon it, it may be laid between the folds of wet paper.

Amphitype.—So called because both positive and negative pictures are produced by it, is another process of Sir J. Herschell's. The paper must be prepared with ferro-tartrate of mercury or lead, or ferro-citrates of the same bases. The salts should be laid on in the state of cream: or, the paper may be saturated with nitrates of the oxides and then dipped in ammonio-citrate or tartrate of iron. Negative pictures are obtained by long exposure, which are not permanent. When faded, it may be restored by dipping it in a solution of pernitrate of mercury till the original picture disappears, (this also requires a long time,) it is then well washed with water and dried, rubbed over with a hot iron between clean papers when a black positive picture at once appears. If the paper had been previously washed with uric acid the pictures produced are much better.

The juices of flowers have been found to be very sensibly effected by light and to produce images by long exposure in the camera: this process is called *anthotype*.

The following are correct directions for preparing Talbotype paper:

Iodizing.—100 grains nitrate of silver dissolved in 3 oz. distilled water; wash the paper evenly with a brush or clean cotton; spread the paper on sheets of blotting paper, till quite dry. Then immerse it in a bath of iodide of potassium 1 oz. and a pint of water, leave it a very few seconds, not more than twenty; then immerse it in distilled water for some minutes, and afterwards pin up by a corner and dry; lastly, pin it up in the sun for at least an hour.

Preparing for Camera.—Wash with 1 part nitrate silver (proportion 50 grains to an ounce water): 6 parts of saturated solution of gallic acid, 2 parts acetic acid; take off superfluous moisture with clean white blotting paper.

To bring out Picture.—1 part nitrate silver (50 grains to an ounce,) 3 parts saturated solution gallic acid; when finished wash in three clean waters; and to fix temporarily, wash with bromide of potassium; proportion of solution 10 grains to 1 oz. distilled water; after some minutes wash and dry.

For final Fixing.—Immerse in hot bath of 1 part of a saturated solution of hyposulphite of soda, to 10 parts water; a couple of minutes will bring out the iodine; lastly, wash with three different hot waters, two or three minutes in each.

Copying Paper.—18 grains salt, dissolved in 1 pint distilled water; soak the paper in a bath of this and dry; then take 30 grains nitrate silver in 1 ounce distilled water; add enough strong ammonia to make it turbid, then clear it by adding more ammonia; with this solution wash your paper with a brush, when dry it is fit for the copying press.

To Fix.—10 grains hyposulphite soda, 1 ounce distilled water; lay the copies in a bath of this after immersing them in 3 baths of warm water; and after the hyposulphite immerse them in three waters and then dry.

Chrysotype.—Paper is washed with a solution of ammonio citrate of iron and dried; the paper should then be of a yellow color, (not brown,) and it is fit to take an image, which, when produced, is faint and hardly perceptible; on removal from the camera, it is washed over with a solution of chloride of gold when the picture is produced, which afterwards darkens. It is then well rinsed with water and washed over with a weak solution of hydriodate of potass.

Energiatype.—A process of Mr. Hunt.—Good letter-paper is washed over with a solution of succinic acid 5 grains, 5 grains common salt, and half a dram of mucilage in 1 oz. of water: when dry, the paper is drawn over the surface of 60 grains of nitrate of silver in 1 oz. distilled water. The paper is dried in the dark and fitted for use. It is white, of a permanent color; 2 or 3 minutes is sufficient to take a portrait. The picture is brought out by passing the paper over a strong solution of proto-sulphate of iron thickened by gum. The paper is then well washed with water, and may be further fastened by weak ammonia or hyposulphite of soda.

Messrs. Langenheim, of Philadelphia, have discovered the art of making photographic pictures on glass, such as portraits, landscape views, copies of daguerreotypes, which is exactly similar to that described by M. Regnault, in behalf of M. Evrard, of Lille, who is said to have discovered it in 1847. The principle of the discovery is a matrix of albumen, rendered sensible to the action of light, by aceto-nitrate of silver, and spread in a thin layer on a plate of glass. The process is to take a certain number of the white of eggs, and remove all the non-transparent part, and then add a few drops of a saturated solution of iodide of potassium, then beat the eggs into froth and allow it to settle. The plate of glass is well cleaned with alcohol, and the albumen is then spread over the glass in a thin layer with another piece of glass. The glass must have a perfect thin coat adhering to it, when it is hung up by one of the corners to drain off the excess. The glass is then placed flat upon a level board, screened from dust and allowed to dry. When dry it is submitted to a good heat, but not so much that the albumen will peel off. After this the glass is dipped into a solution of aceto-nitrate of silver, face downwards, after which it is removed and immersed in a basin of clean water, being stirred in it, for a few seconds, then taken out, held up by a corner, and is completely sensitive, moist or dry, to receive photographic impressions. It is then placed in the camera obscura, after which it is dipped in a bath of gallic acid, to which is added a little of aceto-nitrate of silver. Care is taken not to let the glass remain too long in this. After being dipped in the gallic acid it is washed in water and then immersed in a solution of the bromide of potassium (20 parts to 100 of water), after which it is carefully and well washed in water, and left to dry in a horizontal position in a dark room.

PHOTOMETER. An instrument for measuring the intensity of light, or of illumination.

The one which most usually goes under this name is the photometer invented by the late Sir John Leslie. It is merely the differential thermometer of the same ingenious philosopher, having one of its balls diaphanous, and the other coated with China ink, or blown of deep black enamel; and the whole covered by a case of thin transparent glass, to defend the balls from the disturbing influence of currents of air. The photometer has two general forms; the one *portable* (fig. 1), in which the black ball is about an inch higher than the other, and bent forward to the same vertical line, or the axis of the translucent cylindrical case; and the other *stationary* (fig. 2), having both its balls of the same height, and reclining in opposite ways: the case being composed of a wide cylinder surmounted by the larger segment of a hollow glass sphere. The latter form of the instrument, though less commodious, is better adapted for nice observations; since, besides receiving the light more regularly, its balls, from being on the same level, are not liable to be any how disturbed in their indications by different strata of unequally heated air.

FIG. 1.

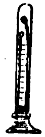
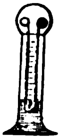


FIG. 2.



The theory of this photometer depends on the assumed principle that the intensity of light is proportional to the heat excited by its incidence on the black ball. When the instrument is exposed to light, the rays which fall on the clear ball pass through it without suffering obstruction; but those which strike the dark ball are stopped and absorbed at its surface, where, assuming a latent form, they act as heat, which, by expanding the air within the ball, causes the liquid in the stem to descend. This heat will continue to accumulate till its farther increase comes to be counteracted by an opposite dispersion, caused by the rise of temperature which the ball has acquired. But, in still air, the rate of cooling is, within moderate limits, proportional to the excess of the temperature of a given surface above that of the surrounding medium. Hence the space through which the colored liquid sinks in the stem will measure the momentary impressions of light, or its actual intensity.

The graduation is entirely arbitrary, and may be regulated according to fancy or convenience. Leslie adopted the same scale of divisions as in the different thermometer, ten degrees of which correspond to one of the centigrade thermometer. When the temperature of both balls is exactly the same, that is, when the instrument is excluded from light, the liquid in the stem next the colored ball stands at zero. In England the direct impression of the sun at noon, about the summer solstice, forces the liquid down to 90° or 100°. The greatest force of the solar beams, in the depth of winter, measure only about 25°. At the altitude of 3° above the horizon, the whole effect of the sun's rays does not exceed one degree. The indirect light of the sky at noon in the summer is from 30° to 40°; in winter from 10° to 15°. Comparing the illuminating power of the solar rays with that of artificial lights, Leslie found the light emitted by the sun 12,000 times more powerful than that of a wax candle; that is to say, if a portion of the luminous solar matter, rather less than half an inch in diameter, were transmitted to our planet, it would throw forth a light equal to the effect of 12,000 candles.

A great objection to this instrument is, that the same quantity of light emitted by terrestrial bodies of different kinds is not always accompanied with the same degree of heat. Thus, phosphorus burns in oxygen gas with intense splendor, and yet gives out far less heat than the comparatively dull combustion of hydrogen in the same gas; and the photometer is more affected by a fire so dull that not a single letter could be discerned in a well-printed page, than by the degree of daylight by which the same page could be read with pleasure and facility.

PHOTOMETRY. The science which treats of the measurement of light. Attempts to determine the relative intensities of different lights were made at an early period in the history of experimental science. For the purpose of comparing the light of Sirius with that of the sun, the celebrated Huygens employed a tube having a very small aperture at one end, into which was inserted a minute globular lens, which allowed only the 27664th part of the solar disc to be seen, and this small portion afforded a light which appeared equally bright with Sirius; whence he concluded the distance of Sirius to be 27664 times greater than that of the sun. Celsius appears to have been the first who proposed to measure light directly by means of what he called a *lucimeter*. His method, however, which was an extremely imperfect one, consisted simply in observing the greatest distance from the eye at which small circles painted on paper were distinctly visible in different lights. It was reserved for Bouguer to establish photomery on true principles. Having been induced by Mairan's remarks on the relative proportion of the sun's light at the summer and winter solstice to investigate the experiment, he undertook a series of experiments.

Lambert afterwards treated the subject more generally, and with great mathematical elegance. The principle adopted by Bouguer and Lambert is extremely simple. Though the eye cannot judge of the proportional force of different lights, it can distinguish in many cases with great precision when two similar surfaces presented together are equally illuminated, or when the shadows of an opaque object thrown upon them by different lights are equally dark. But, as the particles of light proceed in straight lines, they must spread uniformly, and hence their density will diminish in the duplicate ratio of their distances. From the respective situations, therefore, of the centres of divergency when the contrasted surfaces become equally bright, we may easily compute their relative degrees of illumination. The objection to this method is, that the apparatus admits of no certain standard of comparison. Even the light of the sun itself, at the same altitude, and in the same climate, is subject to considerable variation; much more so any artificial light, the force of which must always be influenced by a number of indefinable circumstances. In this respect, therefore, the photometer described in the preceding article has a great and decided advantage.

A simple and elegant application of the principle of Bouguer was made by the late Dr. Ritchie, of London. His apparatus consists of a rectangular box, about an inch and a half or two inches square, open at both ends and blackened within, to absorb extraneous light. Within, inclined at angles of 45° to its axis, are placed two rectangular plates of plane looking-glass, cut from one and the same strip, to insure equality of their reflecting powers, and fastened so as to meet at the top, in the middle of a narrow slit about an inch long, and an eighth of an inch broad, which is covered with a slip of fine tissue or oiled paper. In comparing, by means of this instrument, the illuminating powers of two different sources of light, they must be placed at such a distance from each other, and from the instrument between them, that the light of every part of each shall fall on the reflector next it, and be reflected to the corresponding portion of the oiled paper. The instrument is then moved nearer the one or the other, till the two portions of the paper corresponding to the respective mirrors are equally illuminated, of which the eye can judge with considerable certainty.

The modification of this method, which consists in contrasting the shadows of an opaque object formed by different lights, is usually ascribed to Count Rumford, by whom it was proposed, but was long before used by Lambert. It is generally supposed that the equality of two shadows can be appreciated with more certainty than that of two lights; but, when the lights are of different colors, their estimation by either method admits of little precision.

M. Arago has proposed a method of determining the relative intensities of different lights entirely different in principle from any of the preceding, and probably susceptible of much greater accuracy. It is founded on the properties of polarized light. When two lights are to be compared, the rays from each are polarized by causing them to pass through a plate of tourmaline cut parallel to the axis, or by reflecting them from a plate of glass, on which they fall at the polarizing angle. They are then received on a plate of rock-crystal, cut perpendicularly to the axis, and observed through a doubly refracting prism. Each light will thus give two images tinged with the complementary colors. The images are then brought into such a position that the red of the one falls over the green of the other. If the two lights are equal in intensity, this superposition will produce a white image; if unequal, the image will be slightly colored with red or green, according as the one or the other predominates. The apparatus which this method requires is somewhat complicated, and its manipulation must be attended with considerable trouble.

PIANO-FORTE. A musical stringed instrument of the keyed species. Its name, compounded of two Italian words, signifying *soft* and *loud*, was probably given to it to distinguish it from the harpsichord and spinet, in which no lightness of touch could lessen the strength of the sound produced from the quills always striking the strings with equal force; whereas, in the piano-forte, the strings are put in vibration by means of small hammers, connected by levers with the key or finger board, which hammers quit the string the moment it is struck, a damper falling down upon it the moment the finger quits the key. The invention of the piano-forte is ascribed to a German named Schroeder, who lived at the beginning of last century; but it was first introduced into England in 1766, by Zumpe, by whom it was greatly improved. Within the present century this instrument has received many useful and valuable improvements, at the hands of manufacturers, in this country and Europe: Pianos made in this country preserve their tone better, and even in London a Chickering make is often preferred to a Collard or Errard. Many distinguished musicians have devoted themselves to the composition of pieces for this instrument; and several of the most distinguished composers in modern times, among whom we may mention Hummel, Czerny, Herz, Kalkbrenner, Cramer, Moscheles, Chopin, Thalberg, Liszt, &c., have made the instrument itself almost their exclusive study. It is variously formed, and is designated *grand square*, *semi-grand*, *cabinet*, cottage, and *piccolo*. Some piano-fortes have 7 octaves, but the usual number in the best instrument is 6½. In others 6 or 5½.

One of the recent improvements of this instrument, is that entitled, "the patent dolce campano pedal piano-forte," manufactured by Messrs. Boardman & Gray, of N.Y. The effects produced by the application of this pedal are prolongation of the sound, and the alteration of the quality of tone from the common piano, to that of sweet bells or harps, and which can be used *ad libitum* by the performer, thereby producing not only a charming variety of sound, but a most beautiful accompaniment long sought for the voice. The mechanical part of this improvement is simple, being merely a number of weights, arranged by a lever pedal to fall when required upon an equal number of screws, fixed in the sounding board of a piano, and which of course altering the vibration, effects peculiar qualities and expressions of tone, which, when combined with the other two pedals, produces the lightest shade of altissimo notes, alternating with crescendo and diminuendo, and other musical accents, in imitation of an orchestral performance. Its great advantage are clearness, brilliancy, and delicacy of tone, which falls on the ear like the chimes of distant bells, hence its name "Dolce Campano." The attachment is simple, and may be detached in a few minutes. The Æolian is another attachment put on pianos, which appears to some to produce an agreeable harmony.

PIAZZA. In architecture, a square open space surrounded by buildings. Improperly used in England to denote a walk under an arcade.

PICA. In printing, a type of a moderate size; so called because it was used in printing the *Pic*, the service-book of old Catholic times, which again is supposed to derive its appellation from the *piecolor* of the text and rubric.

PICAMAR. The bitter principle of tar; whence it derives its name.

PICKET. In fortification, a stake used in laying out ground to mark the bounds and angles. Pickets are of various lengths, according to the purpose they are to serve. One end is sharp and shod with iron, and the other sometimes carries a small flag, for the purpose of rendering it visible at a distance.

PICKLES are various kinds of vegetables and fruits preserved in vinegar. The substances are first well cleaned with water, then steeped for some time in brine, and afterward transferred to bottles, which are filled up with good vinegar. Certain fruits, like walnuts, require to be pickled with scalding-hot vinegar; others, as red cabbage, with cold vinegar; but onions, to preserve their whiteness, with distilled vinegar. Wood vinegar is never used by the principal pickle manufacturers, but the best malt or white-wine vinegar, No. 22 or 24. Kitchener says, that by parboiling the pickles in brine, they will be ready in half the time of what they require when done cold. Cabbage, however, cauliflowers, and such articles, would thereby become flabby, and lose that crispness which many people relish. When removed from the brine, they should be cooled, drained, and even dried, before being put into the vinegar. To assist the preservation of pickles, a portion of salt is often added, and likewise, to give flavor, various spices, such as long pepper, black pepper, white pepper, allspice, ginger, cloves, mace, garlic, mustard, horseradish, shallots, capsicum. When the spices are bruised, they are most efficaceous, but they are apt to render the pickle turbid and discolored. The flavoring ingredients of Indian pickle are Curry powder mixed with a large proportion of mustard and garlic. Green peaches are said to make the best imitation of the Indian mango.

PICROMEL. A peculiar substance of a sweetish bitter taste, which exists in bile.

PICROTOXIA. A poisonous bitter principle, which exists in the *Cocculus indicus*.

PIER. In architecture, the solid between the openings of a building, or that from which an arch springs. An abutment pier, in a bridge, is that next the shore. For the mode of building the piers of a bridge, see BRIDGE.

PIER. In engineering, identical with moat, and is used to designate the masses of building erected to form harbors, landing-places, &c.

PIGS. The want of ready and cheap access to foreign markets, led the western farmers to raising hogs and distilling whiskey as a convenient means of taking corn, the great staple, in these shapes to market. Mr Cist, of Ohio, in a communication published in the patent office report for 1847, from which this article is condensed, shows how small a proportion of the corn crop finds its way into the market as meal or grain.

The corn raised in reference to the whiskey market is independent of that which is fed to hogs, no price that can be paid by the distillers affording adequate remuneration to growers of corn who have to transport it far by land carriage.

Cincinnati being the business centre of an immense corn growing and hog raising region, is in fact the principal pork market in the United States, and without even the exceptions of Cork or Belfast, Ireland, the largest in the world.

The business of putting up pork here for distant markets, is of some twenty-six years' standing, but it is only since 1833, that it has sprung into much importance.

The following table furnishes a list of hogs put up each year since 1840, and the prices at which the market opened. The season begins in November and ends in March. Each year refers to that in which business closed.

Year.	No. of Hogs.	Price.
1840	95,000	$3 00 to 3 50
1841	160.000	3 50 " 3 75
1842	220.000	2 00 " 2 50
1843	250,000	1 62 " 2 00
1844	240,000	2 25 " 2 65
1845	213,000	2 50 " 2 70
1846	287.000	4 00 " 4 25
1847	250,000	2 70 " 2 80

The hogs packed in Ohio in

1844 were	560,000
1815 "	450.000
1816 "	425.000
1817 "	325,000

Of which aggregate Cincinnati packed in

1844	43 per cent.
1815	47 "
1816	68 "
1817	70 "

The entire packing of the west for three years may be divided as follows:

	1844.	1845.	1846.
Missouri	16,000	31,700	70,898
Tennessee	16.000	1,500	42,975
Kentucky	91.000	83,800	215,125
Illinois	136,709	67,964	68.120
Indiana	257,414	147,420	251.236
Ohio	560,748	445,538	420,833
Minor Points	1,200	8,850	18,675

The hogs raised for this market are generally a cross of *Irish Grazier*, *Byfield*, *Berkshire*, *Russia*, and *China*, in such proportions as to unite the qualifications of size, tendency to fat and beauty of shape to the hams. They are driven in at the age of from eleven to eighteen months old, in general, although a few reach greater ages. The hogs run in the woods until within five or six weeks of killing time, when they are turned into the corn fields to fatten. If the acorns and beach-nuts are abundant, they require less corn, but the flesh and fat, although hardened by the corn, is not as firm as when they are turned into the corn fields in a less thriving condition, during years when mast as it is called is less abundant.

From the 8th to the 10th of November the pork season begins, and the hogs are sold by the farmers direct to the packers, when the quantity they own justifies it. Some of these farmers drive in one season as high as one thousand head of hogs into their fields. The hogs are driven into pens adjacent to the respective slaughter houses. As soon as the drover or farmer sells to the packer, the hogs are put into small pens, where they are crowded as thick as they can stand, and a hand walks over the drove knocking them on the head successively, with a two pointed hammer adapted to the purpose. They are then dragged out by hooks into the sticking room, where their throats are cut, the blood passing through a drain or sewer below into large tanks prepared to receive it. The blood is saved to be sold together with the hoofs and hair, to the manufacturers of prussiate of potash and prussian blue. Adjacent to the sticking room are the scalding troughs, which are heated by steam. These troughs are of one thousand gallons capacity each. After being scalded, the hogs are tossed by machinery on to a long bench, as many persons getting to work on a hog as can get round it. One cleans out the ear, which work must be done while the hog is reeking with steam, others pull off the bristles and hair, which are thrown on the floor, others again scrape the animal. When these operations are through, his hind legs are stretched open with a stick called a gambril, and the hog is borne off by three men, two of whom carry the front part on their crossed hands, and the other seizes the gambril, by which he carries to the proper place, and slings the hog to a hook which suspends him from the floor. Here the animal falls into the hands of the gutter, who tears out the insides, stripping at the rate of three hogs to the minute. The slaughter houses of Cincinnati are in the outskirts of the city, are ten in number, and fifty by one hundred and thirty feet each in extent—the frames being boarded up with movable lattice work at the sides, which is kept open to admit air in the ordinary temperature, but is shut up during the intense cold which occasionally attends the packing season, so that hogs shall not be frozen so stiff that they cannot be cut up to advantage.

The slaughterers formerly got the gut fat for the whole of the labor thus described, wagoning the hogs more than a mile to the pork houses free of expense to the owners. Every year, however, enhances the value of the perquisites, such as the fat, heart, liver, &c., for food, and the hoofs, hair, &c., for manufacturing purposes. For the last two years, from ten to twenty-five cents per hog have been paid as a bonus for the privilege of killing.

The hauling of hogs from the slaughter house to the packers, is itself a large business, employing fully fifty of the largest class of wagons, each loading from sixty to one hundred and ten hogs at a load.

The hogs are taken into the pork houses from the wagons, and piled up in rows as high as possible. Another set of hands carry them to the scales, where they are usually weighed singly for the advantage of the draft. They are taken hence to the blocks where the head and feet are first struck off, each blow needing no repetition. The hog is then cloven into three parts, separating the ham and shoulder ends from the middle. These are again divided into single hams, shoulders, and sides. The leaf is then torn out, and every piece is distributed, with the exactness and regularity of machinery, to its appropriate pile. The tenderloins, usually two pounds to the hog, are sold to the manufacturers of sausages.

The hog thus cut up into shoulders, hams, and middlings, undergoes further trimming to get the first two articles in proper shape. The size of the hams and shoulders varies with their appropriate markets, and with the price of lard, which, when high, tempts the putter up of pork to trim very close, and indeed to render the entire shoulder into lard. If the pork is intended to be shipped off in bulk, or for the smoke house, it is piled up in vast masses, covered with fine salt in the proportion of fifty pounds salt to two hundred pounds weight of meat. If otherwise, the meat is packed away in barrels with coarse and fine salt in due proportions—no more of the latter being employed than the meat will require for immediate absorption, and the coarse salt remaining in the barrel to renew the pickle whose strength is withdrawn by the meat in process of time.

The different classes of cured pork, packed in barrels, are made up of the different sizes and conditions of hogs—the finest and fattest making clear and mess pork, while the residue is put up into prime pork or bacon. The inspection laws require that clear pork shall be put up of the sides with the ribs out. It takes the largest class of hogs to receive this brand. Mess pork—all sides, with two rumps to the barrel. Prime—for this pork of lighter weight will suffice. Two shoulders, two jowls, and sides enough to fill the barrel, make the contents. Two hundred pounds of meat is required by the inspector, but one hundred and ninety-six pounds, packed here, it is ascertained, will weigh out more than the former quantity in the eastern or southern markets.

The mess pork is used for the commercial marine and the United States navy. This last class, again, is put up somewhat differently, by specifications made out for the purpose. The prime is packed for ship use and the southern markets. The clear pork goes out to the cod and mackerel fisheries. The New Englanders, in the line of pickled pork, buy nothing short of the best.

Bulk pork is that which is intended for immediate use or for smoking. The former class is sent off in flat boats for the lower Mississippi. It forms no important element of the whole, the great mass being sent into the smoke houses, each of which will cure a hundred and seventy-five thousand to five hundred thousand pounds at a time. Here the bacon, as far as possible, is kept until it is actually wanted for shipment, when it is packed in hogsheads containing from eight to nine hundred pounds, the hams, sides, and shoulders, put up each by themselves. The bacon is sold to the iron manufacturing regions of Pennsylvania, Kentucky, and Ohio—to the fisheries of Pennsylvania, Maryland, and Virginia, and to the coast or Mississippi region above New Orleans. Large quantities are disposed of also for the consumption of the Atlantic cities. Flat boats leave here about the first of July, and they all take down more or less bacon for the coast trade.

If there be four hundred and twenty thousand hogs cut up here during the present season, 1847, the product in the manufactured article will be :—

150,000	bbls.	Pork.
21,000,000	lbs.	Bacon.
13,800,000	"	Lard.

These are the products thus far of the pork houses' operations alone. That is to say, the articles thus referred to are put up in these establishments, from the hams, shoulders, sides, leaf lard, and a small portion of the jowls—the residue of the carcases, which are taken to the pork houses, leaving them to enter elsewhere into other departments of manufacture. The relative proportions in weight of bacon and lard rest upon probabilities. An unexpected demand and advance in price of lard would greatly reduce the disparity if not invert the proportion of these two articles. A change in the prospects of the value of pickled pork, during the progress of packing, would also reduce or increase the proportion of barelled pork to the bacon and lard.

The lard made here is exported in packages for the Havana market, where, besides being extensively used, as in the United States, for cooking, it answers the purpose to which butter is applied in this country. It is shipped to the Atlantic markets also, for local use as well as for export to England and France, either in the shape it leaves this market, or in lard oil, large quantities of which are manufactured at the east.

There is one establishment there, which, besides putting up hams, &c., extensively, is engaged in extracting the grease from the rest of the hog. This will probably the present year, 1847, operate upon thirty thousand hogs. It has seven large circular tanks—six of capacity to hold each fifteen thousand pounds, and one to hold six thousand pounds—all gross. These receive the entire carcase with the exception of the hams, and the mass is subjected to steam process under a pressure of seventy pounds to the square inch, the effect of which operation is to reduce the whole to one consistence, and every bone to powder. The fat is drawn off by cocks, and the residuum, a mere earthy substance, as far as made use of, is taken away for manure. Besides the hogs which reach this factory in entire carcases, the great mass of heads, ribs, back bones, tail pieces, feet, and other trimmings of the hogs, cut up at different pork houses, are subjected to the same process, in order to extract every particle of grease. This concern alone will turn out this season three million six hundred thousand pounds lard, five-sixths of which is No. 1. Nothing can surpass the purity and beauty of this lard, which is refined as well as made under steam processes. Six hundred hogs per day pass through these tanks one day with another.

The manufacture of lard oil is accomplished by divesting the lard of one of its constituent parts—stearine. There are probably thirty lard oil factories here on a scale of more or less importance. The largest of these, whose operations are probably more extensive than any other in the United States, has manufactured heretofore into lard oil and stearine, one hundred and forty thousand pounds monthly all the year round. The great increase of hogs for the present season will probably enlarge that business this year fifty per cent.

Eleven million pounds of lard will be run into lard oil this year, two-sevenths of which aggregate will make stearine, the residue lard oil, or in other words, twenty-four thousand barrels of lard oil, of forty to forty-two gallons each. The oil is exported to the Atlantic cities and foreign countries. Much the larger share of this is of inferior lard, made of mast fed and still fed hogs, and the material, to a great extent, comes from a distance, making no part of these tables. Lard oil, besides being sold for what it actually is, enters largely in the eastern cities into the adulteration of sperm oil, and in France serves to reduce the cost of olive oil. The skill of the French chemists enables them to incorporate from sixty-five to seventy per cent. of lard oil with that of the olive. The presence of lard oil can be detected, however, by a deposit of stearine, small portions of which always remain with that article, and will be found at the bottom of the bottle.

The star candles are made of the stearine expressed from the lard in the manufacture of lard oil. The stearine is subjected to hydraulic pressure, by which three-eighths of it is discharged as an impure oleine. This last is employed in the manufacture of soap. Three million pounds of stearine, at least, have been made, in one year, into star candles and soap in these factories, and they are prepared to manufacture six thousand pounds candles average per day throughout the whole year. The manufacture of candles this year will probably approach that amount, as the present supply promises the raw material in abundance.

From the slaughterers the offal capable of producing grease goes to another description of grease extractors, where are also taken hogs dying of disease or by accident, and meat that is spoiling through unfavorable weather or want of care. The grease tried out here goes into the soap manufacture. Lard grease is computed to form eighty per cent. of all the fat used in the making of soap. Of the ordinary soap one hundred thousand pounds are made weekly, equal at four cents per pound to two hundred thousand dollars per annum. This is exclusive of the finer soaps, and of soft soap, which are probably worth twenty-five per cent. more.

Glue to an inconsiderable amount is made of the hoofs of the hogs.

At the rear of these operations comes bristle dressing for the Atlantic markets. This business employs one hundred hands, and affords a product of fifty-five thousand dollars.

Last of all is the disposition of what cannot be used for other purposes, the hair, hoofs, and other offal. These are employed in the manufacture of prussiate of potash, to the product of which also contributes the cracklings or residuum left on expressing the lard. The prussiate of potash is used extensively in the print factories of New England, for coloring purposes. The blood of the hogs is manufactured into prussian blue.

A brief recapitulation of the various manufactures out of the hog at this point present :

150,000	barrels pork	1,875,000	pounds	star candles.
21,000,000	pounds bacon	5,200,000	"	bar soap.
13,800,000	" No. 1 lard	7,300,000	"	fancy and soft soaps.
1,000,000	gallons lard oil	50,000	"	prussiate of potash.

420,000 hogs average, including seven pounds gut fat to each, eighty-four million pounds as the carcase weight when dressed. This is distributed as follows :

150,000 barrels pork—196 pounds net	29,400,000 lbs.
Bacon	21,000,000 "
Number one or leaf lard	13,800,000 "
Lard or grease run into lard oil, stearine, and soap oleine	5,000,000 "
Inferior grease for soap	1,000,000 "
Evaporation, shrinkage, waste cracklings, and offal for manure	13,800,000 "
	84,000,000 lbs.

The value of all this depends of course on the foriegn demand. Last year the pork, bacon, lard, lard oil, star candles, soap, bristles, &c., exceeded six millions of dollars in value. This year it will probably reach eight millions. But for the reduced prices, which a greatly increased product must create, it would far exceed that value.

The buildings in which the pork is put up, are of great extent and capacity, and in every part thoroughly arranged for the business. They generally extend from street to street, so as to enable one set of operations to be carried on without interfering with another. There are thirty of these establishments, besides a number of minor importance.

The stranger here during the packing,

and especially the forwarding season of the article, becomes bewildered in the attempt to keep up with the eye and the memory the various and successive processes he has witnessed, in following the several stages of putting the hog into its final marketable shape, and in surveying the apparently interminable rows of drays which at that period occupy the main avenues to the river in continuous lines going and returning, a mile or more in length, excluding every other use of those streets, from daylight to dark. Nor is his wonder lessened when he surveys the immense quantity of hogsheads of bacon, barrels of pork, and kegs of lard, for which room cannot be found on the pork house floors, extensive as they are, and which are therefore spread over the public landing, and block up every vacant space on the side walks, the public streets, and even adjacent lots, otherwise vacant.

It may appear remarkable, in considering the facilities for putting up pork, which many other points in Illinois, Indiana, Ohio, and Kentucky possess, in their greater contiguity to the neighborhoods which produce the hogs, and other advantages which are palpable, that so large an amount of this business is engrossed at Cincinnati. It must be observed, however, that the raw material in this business (the hog) constitutes sixty per cent. of the value when ready for sale, and being always paid for in cash, such heavy disbursements are required in large sums, and at a day's notice, that the necessary capital is not readily obtainable elsewhere in the west. Nor in an article, which in the process of curing runs great risks in sudden changes of weather, can the packer protect himself, except where there are ample means in extensive supplies of salt, and any necessary force of coopers or laborers, to put on in case of emergency or disappointment in previous arrangements. More than all, the facilities of turning to account in various manufactures, or as articles of food in a populous community, what cannot be disposed of to profit elsewhere, renders hogs to the Cincinnati packer worth at east five per cent. more than they will command at any other point in the Mississippi valley.

As a specimen of the amazing activity which characterizes all the details of packing, cutting, &c., here it may be stated, that two hands, in one of our pork houses, in less than thirteen hours, cut up eight hundred and fifty hogs, averaging over two hundred pounds each, two others placing them on the blocks for the purpose. All these hogs were weighed singly on the scales, in the course of eleven hours. Another hand trimmed the hams (seventeen hundred pieces), in Cincinnati style, as fast as they were separated from the carcases. The hogs were thus cut up and disposed of at the rate of more than one to the minute.

Those who are cognizant to the importance of the domestic market will not be surprised to learn by the table of our exports of pork to foreign countries, the small proportion it forms to the quantity packed. The following is the export table for seven years:

Year.	Barrels.	Year.	Barrels.
1840	66,281	1844	162.689
1841	132,390	1845	161,609
1842	180,039	1846	190,422
1843	80,310		

More than three-fourths of these exports is to British Colonies in America, and to the West India Islands.

Few persons at the east can realize the size, and especially the fatness, to which hogs arrive in the west, under the profuse feeding they receive.

The following are specimens of hogs and lots of hogs killed in Cincinnati this season and the last:

Hogs.	Average weight—lbs.
7	720
5	640
22	403
52	377
50	375

Of these were nine—one litter—weighing respectively 316, 444, 454, 452, 456, 516, 526, 532.

Hogs.	Average weight—lbs.
320	325
657	305

Few if any of these hogs were over nineteen months old. The last lot is extraordinary — combining quantity and weight, even for the west. They were all raised in one neighborhood in Madison county, Kentucky, by Messrs. Caldwell, Campbell, Ross, and Gentry, the oldest being nineteen months in age.

The value of these manufacturing operations to Cincinnati consists in the vast amount of labor they require and create, and the circumstance that the great mass of that labor furnishes employment to thousands, at precisely the very season when their regular avocations cannot be pursued. Thus there are perhaps fifteen hundred coopers engaged in and outside of the city, making lard kegs, pork barrels, and bacon hogsheads: the city coopers at a period when they are not needed on stock barrels and other cooperage, and the country coopers, whose main occupation is farming, during a season when the farms require no labor at their hands. Then there is another large body of hands, also agriculturists, at the proper season, engaged getting out staves and heading, and cutting hoop poles for the same business. Vast quantities of boxes of various descriptions are made for packing bacon, for the Havana and European markets. Lard is also packed to a great extent for export in tin cases or boxes, the making of which furnishes extensive occupation to the tin plate workers.

If we take into view farther that the slaughtering, the wagoning, the pork house labor, the rendering grease and lard oil, the stearine and soap factories, bristle dressing, and other kindred employments, supply abundant occupation to men, who in the spring are engaged in the manufacture and hauling of bricks, quarrying and hauling stone, cellar digging and walling, brick-laying, plastering, and street paving, with other employments, which in their very nature cease on the approach of winter, we can readily appreciate the importance of a business which supplies labor to the industry of probably six thousand individuals, who but for its existence would be earning little or nothing one-third of the year.

The United States census of 1840 gives 26,301,293, as the existing number of hogs of that date. The principal increase since is in the west owing to the abundance of corn there, and that quantity may be now safely enlarged to forty-five millions. This is about the number assigned to entire Europe in 1839, by McGregor, in his Commercial Dictionary, and there is probably no material increase there since, judging by the slow advance in that section of the world in productions of any kind.

PIN MANUFACTURE. A pin is a small bit of wire, commonly brass, with a point at one end, and a spherical head at the other. In making this little article, there are no less than fourteen distinct operations:—1. *Straightening the wire.* The wire, as obtained from the drawing frame, is wound about a bobbin or barrel, which gives it a curvature that must be removed. The straightening engine is formed by fixing 6 or 7 nails upright in a waving line on a board, so that the void space measured in a straight line between the first three nails may have exactly the thickness of the wire to be trimmed; and that the other nails may make the wire take a certain curve line, which must vary with its thickness. The workman pulls the wire with pincers through among these nails, to the length of about 30 feet, at a running draught; and after he cuts them off, he returns for as much more; he can thus finish 600 fathoms in the hour. He next cuts these long pieces into lengths of 3 or 4 pins. A day's work of one man amounts to 18 or 20 thousand dozen of pin-lengths. —2. *Pointing* is executed on two iron or steel grindstones, by two workmen, one of whom roughens, and the other finishes. Thirty or forty of the pin wires are applied to the grindstone at once, arranged in one plane, between the two forefingers and thumbs of both hands, which give them a rotatory movement.—3. *Cutting these wires into pin-lengths.* This is done by an adjusted chisel.—4. *Twisting of the wire for the pin-heads.* These are made of a much finer wire, coiled into a compact spiral, round a wire of the size of the pins, by means of a small lathe constructed for the purpose. —5. *Cutting the heads.* Two turns are dexterously cut off for each head, by a regulated chisel. A skilful workman may turn off 12,000 in the hour.—6. *Annealing the heads.* They are put into an iron ladle, made red-hot over an open fire, and then thrown into cold water.—7. *Stamping or shaping the heads.* This is done by the blow of a small ram. The pin-heads are also fixed on by the same operative, who makes about 1500 pins in the hour, or from 12,000 to 15,000 per diem; exclusive of one-thirteenth, which is always deducted for waste in this department, as well as in the rest of the manufacture.—8. *Yellowing or cleaning the pins* is effected by boiling them for half an hour in sour beer, wine lees, or solution of tartar; after which they are washed.—9. *Whitening or tinning.* A stratum of about 6 pounds of pins is laid in a copper pan, then a stratum of about 7 or 8 pounds of grain tin; and so alternately till the vessel be filled; a pipe being left inserted at one side, to permit the introduction of water slowly at the bottom, without deranging the contents. When the pipe is withdrawn, its space is filled up with grain tin. The vessel being now set on the fire, and the water becoming hot, its surface is sprinkled with 4 ounces of cream of tartar; after which it is allowed to boil for an hour. The pins and tin grains are, lastly, separated by a kind of cullender.—10. *Washing the pins* in pure water. —11. *Drying and polishing them*, in a leather sack, filled with coarse bran, which is agitated to and fro by two men. —12. *Winnowing*, by fanners.—13. *Pricking the papers* for receiving the pins.—14. *Papering*, or fixing them in the paper. This is done by children, who acquire the habit of putting up 36,000 per day.

The pin manufacture is one of the greatest prodigies of the division of labor; it furnishes 12,000 articles for the sum of three shillings, which have required the united diligence of fourteen skilful operatives.

The above is an outline of the mode of manufacturing pins by hand labor, but several beautiful inventions have been employed to make them entirely, or in a great measure, by machinery; and there are extensive manufactures of these articles in the Northern States.

PINCHBECK. An alloy of copper of zinc; a species of brass much resembling what is now termed *Mosaic gold*. It was brought into notice by a person of the above name.

PIPES, Glass Water Pipes. Glass tubes are now coming into a very general use for conveying water. Mr. Wm. T. De Golyer, of Schenectady, N. Y., has a patent for making tubes of such a form as to couple different lengths together, and form glass conductors for water, of any length. About 1000 rods of glass pipes of different diameters have already been laid down; and Mr. John Matthews, of First Avenue, N. Y., has tested the strength of a pipe 1¼ inch in diameter, made at the Albany Glass Works, and found it capable of standing a pressure of 200 lbs. to the square inch, or a column of water 450 feet high. Mr. Wilson, of Hastings, a few miles out of New York, has connected these glass tubes with a hydraulic ram to stand a pressure of 80 feet high. After the joints were cemented only four days, the water was let on, and the joints were found perfectly tight. It is well known that glass is almost anti-corrosive, and resists all action of the elements of air and every kind of water for a long time; it is therefore indestructible, and when kept from the action of frost, it may be considered as enduring as the everlasting hills. By them water is conveyed in all its purity from the fountain, as the interior is too smooth to allow any weeds or vegetable formations to adhere to it.

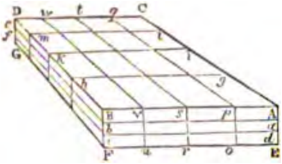
PIPES, Sheet Iron. Sheet iron pipes of a new manufacture have lately been introduced into England, from France, where they have been in use for several years. They are made of sheet iron, which is bent to the required form and then strongly riveted together; after which they are coated with an alloy of tin, and the longitudinal joints are soldered so as to render them both air-tight and water-proof. In order to give them more stiffness, they are next coated on the outside with asphalt cement, and, if they are intended to be used as water-pipes, the inside is also coated with bitumen, which resists, like glass, the action of acids and alkalies. They are so elastic that they will bear a considerable deflection without injuring the pipes, or causing any leakage at the joints. The vertical joints screw together in the same manner as cast iron gas-pipes. These pipes have been used for water, for gas, and for draining, and are found to be more economical than cast iron, besides being less liable to leak, and for water-pipes they are more healthy than the common ones.

Iron pipe coated with glass.—At a late *Soiree* of the President of the Society of Civil Engineers, London, some specimens of iron manufacture were exhibited, coated with glass, from the Smethwick Iron Works of Messrs. Selby and Johns, near Birmingham, and which would appear to be the very desideratum so long sought for. In the process of coating plates, corrugated or plain roofing, tiles, tubing of all kinds and dimensions, frying-pans, grid-irons, sauce-pans, kettles, caldrons, or boilers, in lieu of coppers, and a host of other implements, domestic, agricultural, and manufacturing; the article is first thoroughly cleansed in an acid solution, to free it from every particle of grease, similar to the preparation for tinning, zincing, &c. It is then covered with a glutinous preparation, over which is laid a coat of glass, ground to a fine powder.

The article is then introduced into a furnace of peculiar construction and sufficient temperature, in which the glass is fused, and the intermediate glutinous matter being evaporated, the glass fills the external pores of the metal, and becomes firmly united to it; as the manipulation becomes facilitated by practice, it is probable that the cost of a glass-coated iron material, of these common kinds, will be but a mere nominal trifle more than the plain articles themselves.

The dinner plates shown were four ounces lighter than an earthenware plate of the best construction, size for size. The foliage and designs are in relief, and are executed by a kind of stenciling; one color being put on, it is transferred to the kiln and fixed; then, when cold, another color is added, again fixed, and so on until the whole pattern is applied.

PIT COAL. Under the article COAL, some remarks connected with the nature of the deposit, and the extent of its beds in this country are given. Under the present will be considered chiefly its connection with the basin form, and the want of horizontality of the beds, which induces the necessity of sinking shafts, and *mining*, to bring it to the surface. The majority of the pit coal is found in the carboniferous limestone formation, or that of the system of rocks found in Northern Pensylvania, and which lie immediately above the *old red sandstone*, the Potsdam sandstone of the New York system of rocks. It is rare indeed to find coal in a stratum rock higher than the mountain limestone, although it does occur in the oolitic or upper secondary rocks. Such is the position of the bed of coal at Richmond, Virginia.



View of a Horizontal Coal-Field.

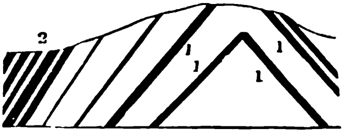
The simplest form of a coal-field is the entirely basin shape, in which the beds crop out all round, and dip down toward the centre.

These basins are generally elliptical, sometimes nearly circular, but are often very eccentric, being much greater in length than in breadth; and frequently one side of the basin on the shorter diameter has a much greater dip than the other, which circumstance throws the trough or lower part of the basin concavity much nearer to the one side than to the other. From this view of one entire basin, it is evident that the dip of the coal strata belonging to it runs in opposite directions, on the opposite sides, and that all the strata regularly crop out, and meet the alluvial cover in every point of the circumferential space, like the edges of a nest of common basins.

It is from this basin shape that all the other coal-fields are formed, which are segments of a basin produced by slips, dikes, or dislocations of the strata. If the coals were dislocated by two slips—one slip throwing the strata *down* to the east, and the other slip throwing them as much *up* in the same direction, the outcrops of the coals would be found at some distance around.

The chief difficulty in exploring a country in search of coal, or one where coal-fields are known to exist, arises from the great thickness of alluvial and other cover, which completely hides the outcrop or basset edge of the strata, called by miners the *rock-head*; as also the fissures, dikes, and dislocations of the strata, which so entirely change the structure and bearings of coal-fields, and cause often great loss to the mining adventurer. The alluvial cover, on the other hand, is beneficial, by protecting the seams of the strata from the superficial waters and rains, which would be apt to drown them, if they were naked.

The accompanying cut is a good illustration of a coal-field which has undergone alterations since its deposition:—



Here we see it broken into three subordinate coal-fields, formed by two great faults or dislocations of the strata; but, independently of these fractures across the whole series, the strata continue quite regular in their respective alternations, and preserve nearly unchanged their angle of inclination to the horizon. The section shows a south coal-field dipping northerly, till it is cut across by an extensive slope, which dislocates the coal and the parallel strata to the enormous extent of 1230 feet, by which all the coals have been thrown up, not simply to the day, but are not found again till we advance nearly a mile northward, on the line of the dip, where the identical seams of coal, shale, &c. are observed once more with their regular inclination. These coals of the middle area, dip regularly northward till interrupted by a slip running opposite, which dislocates the strata, and throws them up 700 feet; that is to say, a line prolonged in the direction of any one well-known seam, will run 700 feet above the line of the same seam as it emerges after the middle slip. Immediately adjoining the last slip, the coals and coal-field resume their course, and dip regularly northward, running through a longer range than either of the other two members of the basin.

With regard to slips in coal-fields, there is a general law connected with them as to the position of the dislocated strata, which is this:—When a slip is met with in the course of working the mines—if when looking to it, the vertical line of the slip or fissure, it forms an acute angle with the line of the pavement upon which the observer stands, we are certain that the strata are dislocated downwards upon the other side of the fissure. On the contrary, if the angle formed by the two lines above-mentioned is obtuse, we are certain that the strata are dislocated or thrown upwards upon the other side of the fissure. When the angle is 90°, or a right angle, it is altogether uncertain whether the dislocation throws up or down on the opposite side of the slip. When dikes intercept the strata, they generally only separate the strata the width of the dike, without any dislocation, either up or down; so that if a coal is intercepted by a dike, it is found again by running a mine directly forward, corresponding to the angle or inclination of the coal with the horizon.

The following is the description of the several varieties of coal as given by Dr. Ure:—

1. *Cubical coal.*—It is black, shining, compact, moderately hard, but easily frangible. When extracted in the mine, it comes out in rectangular masses, of which the smaller fragments are cubical. The lamellæ (*reed* of the coal) are always parallel to the bed or plane on which the coal rests; a fact which holds generally with this substance. There are two varieties of cubical coal: the *open-burning* and the *caking*. The latter, however small its fragments may be, is quite available for fuel, in consequence of its agglutinating into a mass at a moderate heat, by the abundance of its bitumen. This kind is the true smithy or forge-coal, because it readily forms itself into a vault round the blast of the bellows, which serves for a cupola in concentrating the heat on objects thrust into the cavity.

The open-burning cubical coals are known by several local names; the rough coal or clod coal, from the large masses in which they may be had, and the cherry coal, from the cheerful blaze with which they spontaneously burn; whereas the caking coals, such as most of the Newcastle qualities, require to be frequently poked in the grate. Its specific gravity varies from 1·25 to 1·4.

2. *Slate or splint coal.*—This is dull-black, very compact, much harder, and more difficultly frangible than the preceding. It is readily fissile, like slate, but powerfully resists the cross fracture, which is conchoidal. Specific gravity from 1·26 to 1·40. In working, it separates in large quadrangular sharp-edged masses. It burns without caking, produces much flame and smoke, unless judiciously supplied with air, and leaves frequently a considerable bulk of white ashes. It is the best fuel for distilleries and all large grates, as it makes an open fire, and does not clog up the bars with glassy scoriæ. I found good splint coal of the Glasgow field to have a specific gravity of 1·266, and to consist of—carbon, 70·9; hydrogen, 4·3; oxygen, 24·8.

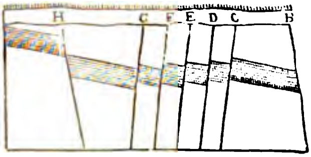
3. *Cannel coal.*—Color between velvet and grayish black; lustre resinous; fracture even; fragments trapezoidal; hard as splint coal; specific gravity 1·23 to 1·28. In working, it is detached in four-sided columnar masses, often breaks conchoidal, like pitch, kindles very readily, and burns with a bright white projective flame, like the wick of a candle, whence its name. It occurs most abundantly in the coal-field of Wigan, in Lancashire, in a bed 4 feet thick; and there is a good deal of it in the Clydesdale coal-field, of which it forms the lowest seam that is worked. It produces very little dust in the mine, and hardly soils the fingers with carbonaceous matter. Cannel coal from Woodhall, near Glasgow, specific gravity 1·228, consists by my analysis of—carbon, 72·22; hydrogen, 3·93; oxygen, 21·05; with a little azote (about 2·8 in 100 parts). This coal has been found to afford, in the Scotch gas-works, a very rich-burning gas. The azote is there converted into ammonia, of which a considerable quantity is distilled over into the tar-pit.

4. *Glance coal.*—This species has an

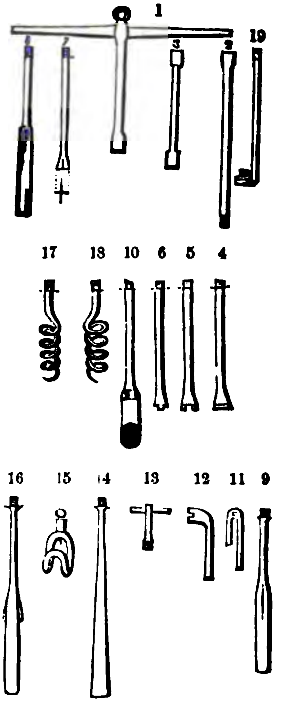
iron-black color, with an occasional iridiscence, like that of tempered steel; lustre in general splendent, shining, and imperfect metallic; does not soil; easily frangible; fracture flat conchoidal; fragments sharp-edged. It burns without flame or smell, except when it is sulphureous; and it leaves a white-colored ash. It produces no soot, and seems, indeed, to be merely carbon, or coal deprived of its volatile matter or bitumen, and converted into coke by subterranean calcination, frequently from contact with whin-dikes. Glance coal abounds in Ireland, under the name of Kilkenny coal; in Scotland it is called blind coal, from its burning without flame or smoke; and in Wales, it is the malting or stone coal. It contains from 90 to 97 per cent. of carbon. Specific gravity from 1·3 to 1·5; increasing with the proportion of earthy impurities.—(*Ure.*)

Dikes and faults are denominated upthrow or downthrow, according to the position they are met with in working the mine. Thus, in figure (p. 466), if the miner in advancing to the rise, the dike A B obviously does not change the direction; but C D is a downthrow dike of a certain number of fathoms towards the rise of the basin, and E F is an upthrow dike likewise towards the rise. On the other hand, when the dikes are met with by the miner in working from the rise to the dip, the names of the above dikes would be reversed; for what is an upthrow in the first case, becomes a downthrow in the second, relative to the mining operations.

We have seen that *hitches* are small and partial slips where the dislocation does not exceed the thickness of the coal-seam; and they are correctly enough called *steps* by the miner. This figure represents the operation of the *hitches* A, B, C, D, E, F, G, H, on the coal measures, though observed in one or two seams of a field, they may not appear in the rest, as is the case with dikes and faults.



The boring tools used for mining for coal are given below:—



1. The brace-head.
2. The common rod.
3. The double-box rod; intermediate piece.
4. The common chisel.
5 The indented chisel
6 Another of the same.
7. The cross-mouthed chisel.
8. The wimble
9. The sludger, for bringing up the mud.
10. The rounder.
11. The key for supporting the train of rods at the bore-mouth.
12. The key for screwing together and asunder the rods.
13 The topit, or top-piece.
14. The beche, for catching the rod when it breaks in the bore.
15 The runner, for taking hold of the topit.
6 The tongued chisel.
17 The right-handed worm-screw.
18 The left-handed do.
19. The finger grip or catch.

Of fitting or winning a coal-field.—In sinking a shaft for working coal, the great obstacle to be encountered is water, particularly in the first opening of a field, which proceeds from the surface of the adjacent country; for every coal stratum, however deep it may lie in one part of the basin, always rises till it meets the alluvial cover, or crops out, unless it be met by a slip or dike. When the basset-edge of the strata is covered with gravel or sand, any body or stream of water will readily percolate downwards through it, and fill up the porous interstices between the coal-measures, till arrested by the face of a slip, which acts as a valve or flood-gate, and confines the water to one compartment of the basin, which may, however, be of considerable area, and require a great power of drainage.

In reference to water, coal-fields are divided into two kinds:—1, level free coal; 2, coal not level free. In the practice of mining, if a coal-field, or portion of it, is so situated above the surface of the ocean, that a level can be carried from that plane till it intersects the coal, all the coal above the plane of intersection is said to be level free; but if a coal-field, though placed above the surface of the ocean, cannot, on account of the expense, be drained by a level or gallery, but by mechanical power, such a coal-field is said to be not level free.

Besides these general levels of drainage, there are subsidiary levels, called off-takes or drifts, which discharge the water of a mine, not at the mouth of the pit, but at some depth beneath the surface, where, from the form of the country, it may be run off level free. From 20 to 30 fathoms off-take is an object of considerable economy in pumping; but even less is often had recourse to; and when judiciously contrived, may serve to intercept much of the crop water, and prevent it from getting down to the dip part of the coal, where it would become a heavy load on a hydraulic engine.

Day levels were an object of primary importance with the early miners, who had not the gigantic pumping power of the steam-engine at their command. Levels ought to be no less than 4 feet wide, and from 5 feet and a half to 6 feet high; which is large enough for carrying off water, and admitting workmen to make repairs and clear out depositions. When a day-level, however, is to serve the double purpose of drainage and an outlet for coals, it should be nearly 5 feet wide, and have its bottom gutter covered over. In other instances a level not only carries off the water from the colliery, but is converted into a canal for bearing boats loaded with coals for the market. Some subterranean canals are nine feet wide, and twelve feet high, with five feet depth of water.

If in the progress of driving a level, workable coals are intersected before reaching the seam which is the main object of the mining adventure, an air-pit may be sunk, of such dimensions as to serve for raising the coals. These air-pits do not in general exceed 7 feet in diameter; and they ought to be always cylindrical.

When a coal-basin is so situated that it cannot be rendered level free, the winning must be made by the aid of machinery. The engines at present employed in the drainage of coal-mines are:—

1. The water wheel, and water-pressure engine.
2. The atmospheric steam-engine of Newcomen.
3. The steam-engine, both atmospheric and double-stroke, of Watt.
4. The expansion steam-engine of Woolf.
5. The high-pressure steam-engine without a condenser.

The depth at which the coal is to be won, or to be drained of moisture, regulates the power of the engine to be applied, taking into account the probable quantity of water which may be found, a circumstance which governs the diameter of the working barrels of the pumps. Experience has proved, that in opening collieries, even in new fields, the water may generally be drawn off by pumps of from 10 to 15 inches diameter; excepting where the strata are connected with rivers, sand-beds filled with water, or marsh-lands. As feeders of water from rivers or sand-beds may be hindered from descending coal-pits, the growth proceeding from these sources need not be taken into account; and it is observed, in sinking shafts, that though the influx which cannot be cut off from the mine, may be at first very great, even beyond the power of the engine for a little while, yet as this excessive flow of water is frequently derived from the drainage of fissures, it eventually becomes manageable. An engine working the pumps for 8 or 10 hours out of the 24, is reckoned adequate to the winning of a new colliery, which reaps no advantage from neighboring hydraulic powers.

When the engine-pit is sunk, and the

lodgment formed, a mine is then run in the coal to the rise of the field, or a cropping from the engine-pit to the second pit. This mine may be 6 or 8 feet wide, and carried either in a line directly to the pit bottom, or at right angles to the backs or web of the coal, until it is on a line with the pit, where a mine is set off, upon one side, to the pit bottom. This mine or gallery is carried as nearly parallel to the backs as possible, till the pit is gained. The next step is to drive the drip-head or main-levels from the engine-pit bottom, or from the dip-hand of the backset immediately contiguous to the engine-pit bottom. In this business, the best colliers are always employed, as the object is to drive the gallery in a truly level direction, independently of all sinkings or risings of the pavement. For coal seams of ordinary thickness, this gallery is usually not more than 6 feet wide; observing to have on the dip side of the gallery a small quantity of water, like that of a gutter, so that it will always be about 4 or 6 inches deep at the forehead upon the dip-wall. When the level is driven correctly, with the proper depth of water, it is said to have dead water at the forehead. In this operation, therefore, the miner pays no regard to the backs or cutters of the coal; but is guided in his line of direction entirely by the water level, which he must attend to solely, without regard to slips or dislocations of the strata throwing the coal up or down.

We shall now describe briefly the modern modes of working coals a-dipping of, and deeper than, the engine-pit bottom. One of these consists in laying a working pump barrel with a long windbore at the bottom of the downset mine, furnished with a smooth rod working through a collar at the top of the working barrel. At one side of this, near the top, a kneed pipe is attached, and from it pipes are carried to the point of delivery, either at the engine-pit bottom or day-level. The spears are worked sometimes by rods connected with the machinery at the surface; in which case the spears, if very long, are either suspended from swing or pendulum rods, or move on friction rollers. But since the action of the spears, running with great velocity the total length of the engine stroke, very soon tears every thing to pieces, the motion of the spears under ground has been reduced from 6 or 8 feet, the length of the engine stroke, to about 15 inches; and the due speed in the pump is effected by the centring of a beam, and the attachment of the spears to it. The spears are fastened by a strong bolt, which passes through the beam; and there are several holes, by means of which the stroke in the pumps can be lengthened or shortened at convenience. The movement of the spears is regulated by a strong iron quadrant or wheel at the bottom.

In level free coals, these pumps may be worked by a water-wheel, stationed near the bottom of the pit, impelled by water falling down the shaft, to be discharged by the level to the day (day-level).

But the preferable plan of working under-dip coal, is that recently adopted by the Newcastle engineers (England); and consists in running a mine a-dipping of the engine-pit, in such direction of the dip as is most convenient; and both coals and water are brought up the rise of the coal by means of high pressure engines, working with a power of from 30 to 50 pounds on the square inch. These machines are quite under command, and, producing much power in little space, they are the most applicable for underground work. An excavation is made for them in the strata above the coal, and the air used for the furnace under the boiler, is the returned air of the mine ventilation. In the dip-mine a double tram-road is laid; so that while a number of loaded corves are ascending, an equal number of empty ones are going down. Although this improved method has been introduced only a few years back, under-dip workings have been already executed more than an English mile under-dip of the engine-pit bottom, by means of three of these high-pressure engines, placed at equal distances in the under-dip mine. It may hence be inferred, that this mode of working is susceptible of most extensive application; and in place of sinking pits of excessive depth upon the dip of the coal, at an almost ruinous expense, much of the under-dip coal will in future be worked by means of the actual engine pits. In the Newcastle district, coals are now working in an engine-pit 115 fathoms deep under-dip of the engine-pit bottom, above 1600 yards, and fully 80 fathoms of perpendicular depth more than the bottom of the pit.

If an engine-pit be sunk to a given coal at a certain depth, all the other coals of the coal-field, both above and below the coal sunk to, can be drained and worked to the same depth, by driving a level cross-cut mine, both to the dip and rise, till all the coals are intersected.

PLANK ROADS. The manifest advantage of these roads over every other, has led to their general adoption in some of the Western States, and their general extension through the western part of this State (N. Y.). Next to steam railroads, they are the most useful form of road for conveyance.

In the most generally approved system of construction, two parallel rows of small sticks of timber (called indifferently sleepers, stringers or sills) are imbedded in the road, three or four feet apart. Plank, eight feet long and three inches thick, are laid upon those sticks across them, at right angles to their direction. A side track of earth, to turn out upon, is carefully graded. Deep ditches are dug on each side, to insure perfect drainage; and thus is formed a plank road.

Laying them out.—In laying out a plank road, it is indispensable, in order to secure all the benefits which can be derived from it, to avoid or cut down all steep ascents.

A very short rise of even considerable steepness may, however, be allowed to remain, to save expense; since a horse can, for a short time, put forth extra exertion to overcome such an increased resistance; and the danger of slipping is avoided by descending upon the earthen track.

A double plank track will rarely be necessary.

No one without experience in the matter can credit the amount of travel which one such track can accommodate. Over a single track near Syracuse, 161,000 teams passed in two years, averaging over 220 teams per day, and during three days 720 passed daily. The earthen turn-out track must, however, be kept in good order; and this is easy, if it slope off properly to the ditch, for it is not cut with any continuous lengthwise ruts, but is only passed over by the wheels of the wagons which turn off from the track and return to it. They thus move in curves, which would very rarely exactly hit each other, and this travel, being over the earth, tends to keep it in shape rather than to disturb it.

Covering.—The planks having been properly laid, as has been directed, should be covered over an inch in thickness with very fine gravel or pebbles, from which all the stones or pebbles are to be raked, so as to leave nothing upon the surface of the road that could be forced into and injure the fibres of the planks. The grit of the sand soon penetrates into the grain of the wood and combines with the fibres and the dropping upon the road to form a hard and tough covering like felt, which greatly protects the wood from the wheels and horses' shoes. Sawdust and tan-bark have also been used.

The road is now ready for use.

Laying.—The planks should be laid directly across the road, at right angles, or "square," to its line. The ends of the planks are not laid evenly to a line, but project three or four inches on each side alternately, so as to prevent a rut being formed by the side of the plank track, and make it easier for loaded wagons to get upon it, as the wheels, instead of scraping along the ends of the planks when coming towards the track obliquely after turning off, will, on coming square against the edge of one of those projecting planks, rise directly upon it. On the Canada roads every three planks project three inches on each side of the road alternately.

Durability.—A plank road may require a renewal either because it has worn out at top by the travel upon it, or because it has been destroyed at the bottom by rot. But, if the road have travel enough to make it profitable to its builders, it will wear out first, and if it does, it will have earned abundantly enough to replace it twice over, as we shall see presently. The liability to decay is therefore a secondary consideration on roads of importance.

Decay.—As to natural decay, no hemlock road has been in use long enough to determine how long the plank can be preserved from rot. Seven years is perhaps a fair average. Different species of hemlock vary greatly; and upland timber is always more durable than from low and wet localities. The pine roads in Canada generally last about eight years, varying from seven to twelve. The original Toronto road was used chiefly by teams hauling steamboat wood, and at the end of not six years began to break through in places, and not being repaired, was principally gone at the end of ten years. Having been poorly built, badly drained, not sanded, and no care bestowed upon it, it indicates the minimum of durability. Oak plank cross-walks are in Detroit, the plank being laid flat as on those of pine. It is believed that oak plank, well laid, would last at least twelve or fifteen years. One set of sleepers will outlast two plankings. Several Canada roads have been relaid upon the old sleepers, thus much lessening the cost of renewal.

The following table shows the number of Plank Roads in the State of New York:

Name.	Opened.	Miles.
Great Western Albany	1849	11
Fonda and Garoga	1845	18
Fultonville and Johnstown	1849	5
Rome and Utica	1848	15
Utica and Burlington	1849	5¼
Rome and Oswego	1847	60
Rome and Western	1849	11
Rome and Taberg	1849	9
Rome and Madison	1849	22
Salina and Central	1847	16
Syracuse and Manlius	1844	8
Syracuse and Bridgeport	1849	12
Syracuse and Oswego	1840	32
Syracuse and Liverpool	1849	11
Syracuse and Tully	1848	25
Split Rock Head	..	..
Hannibal and Oswego	1848	11
Hannibal and Oswego	1849	5

Total 276¼ miles. The tolls which the farmers pay are not taxes, in one sense of the term—they are saved in the larger loads they are enabled to draw, the greater speed at which they are enabled to travel, the wear and tear of harness, gearing, and animal strength; and the pleasure of riding on a smooth plank road in comparison with an old corderoy one is very great

PLASTER OF PARIS. (*See* GYPSUM.)

PLATED MANUFACTURE. The silver in this case is not applied to ingots of pure copper, but to an alloy consisting of copper and brass, which possesses the requisite stiffness for the various articles.

The furnace used for melting that alloy, in black-led crucibles, is a common air-furnace, like that for making brass.

The ingot-moulds are made of cast-iron, in two pieces, fastened together; the cavity being of a rectangular shape, 3 inches broad, 1¼ thick, and 18 or 20 long. There is an elevated mouth-piece or gate, to give pressure to the liquid metal, and secure solidity to the ingot. The mould is heated, till the grease with which its cavity is besmeared merely begins to smoke, but does not burn. The proper heat of the melted metal for casting, is when it assumes a bluish color, and is quite liquid. Whenever the metal has solidified in the mould, the wedges that tighten its rings are driven out, lest the shrinkage of the ingot should cause the mould to crack. (*See* BRASS.)

The ingot is now dressed carefully with the file on one or two faces, according as it is to be single or double plated. The thickness of the silver plate is such as to constitute one-fortieth of the thickness of the ingot; or when this is an inch and a quarter thick, the silver plate applied is one thirty-second of an inch; being by weight a pound troy of the former, to from 8 to 10 pennyweights of the latter. The silver, which is slightly less in size than the copper, is tied to it truly with iron wire, and a little of a saturated solution of borax is then insinuated at the edges. This salt melts at a low heat, and excludes the atmosphere, which might oxydize the copper, and obstruct the union of the metals. The ingot thus prepared is brought to the plating furnace.

The furnace has an iron door with a small hole to look through; it is fed with coke, laid upon a grate at a level with the bottom of the door. The ingot is placed immediately upon the coke, the door is shut, and the plater watches at the peep-hole the instant when the proper soldering temperature is attained. During the union of the silver and copper, the surface of the former is seen to be drawn into immediate contact with the latter, and this species of *riveting* is the signal for removing the compound bar instantly from the furnace. Were it to remain a very little longer, the silver would become alloyed with the copper, and the plating be thus completely spoiled. The adhesion is, in fact, accomplished here by the formation of a film of true silver-solder at the surfaces of contact.

The ingot is next cleaned, and rolled to the proper thinness between cylinders; being in its progress of lamination frequently annealed on a small reverberatory hearth. After the last annealing, the sheets are immersed in hot diluted sulphuric acid, and scoured with fine Calais sand; they are then ready to be fashioned into various articles.

In plating copper wire, the silver is first formed into a tubular shape, with one edge projecting slightly over the other; through which a red-hot copper cylinder being somewhat loosely run, the silver edges are closely pressed together with a steel burnisher, whereby they get firmly united. The tube, thus completed, is cleaned inside, and put on the proper copper rod, which it exactly fits. The copper is left a little longer than its coating tube, and is grooved at the extremities of the latter, so that the silver edges, being worked into the copper groove, may exclude the air from the surface of the rod. The compound cylinder is now heated red-hot, and rubbed briskly over with the steel burnisher in a longitudinal direction, whereby the two metals get firmly united, and form a solid rod, ready to be drawn into wire of any requisite fineness and form; as flat, half-round, fluted, or with mouldings, according to the figure of the hole in the draw-plate. Such wire is much used for making bread-baskets, toast-racks, snuffers, and articles combining elegance with lightness and economy. The wire must be annealed from time to time during the drawing, and finally cleaned, like the plates, with diluted acid.

The greatest improvement made in this branch of manufacture, is the introduction of silver edges, beads, and mouldings, instead of the plated ones, which from their prominence had their silver surface speedily worn off, and thus assumed a brassy look. The silver destined to form the ornamental edgings is laminated exceedingly thin; a square inch sometimes weighing no more than 10 or 12 grains. This is too fragile to bear the action of the opposite steel dies of the swage above described. It is necessary, therefore, that the sunk part of the die should be steel, and the opposite side lead, as was observed in the stamping; and this is the method now generally employed to form these silver ornaments. The inside shell of this silver moulding is filled with soft solder, and then bent into the requisite form.

The base of candlesticks is generally made in a die by the stamp, as well as the neck, the dish part of the nozzle or socket, and the tubular stem or pillar. The different parts are united, some with soft and others with hard solder. The branches of candlesticks are formed in two semi-cylindrical halves, like the feet of tea-urns. When an article is to be engraved on, an extra plate of silver is applied at the proper part, while the plate is still flat, and fixed by burnishing with great pressure over a hot anvil. This is a species of welding.

The last finish of plated goods is given by burnishing-tools of bloodstone, fixed in sheet-iron cases, or hardened steel, finely polished.

The ingots for lamination might probably be plated with advantage by the delicate pressure process employed for silvering copper wire.

Much of the silver in plated ware is now laid on by electric deposition; and old articles are re-silvered by this process which can not occur in the old way. For a description of the process, see the article ELECTRO-METALLURGY.

PLATE POWDER is made by mixing 4 oz. of prepared chalk with 1 oz. of quick-silver, prepared with manna and chalk. Or, 8 oz. of polisher's putty, 8 oz. of hartshorn, and 1 pound of whiting.

PLATINA-MOHR. Platinum-black. The following is Doberiener's method of making this powder:—

Melt platina ore with double its weight of zinc, reduce the alloy to powder, and treat it first with dilute sulphuric acid, and next with dilute nitric acid, to oxydize and dissolve out all the zinc, which, contrary to one's expectations, is somewhat difficult to do, even at a boiling heat. The insoluble black-gray powder contains some osmiuret of iridium, united with the crude platinum. This compound acts like simple platina-black, after it has been purified by digestion in potash lye, and washing with water. Its oxydizing power is so great, as to transform not only the formic acid into the carbonic, and alcohol into vinegar, but even some osmic acid, from the metallic osmium. The above powder explodes by heat like gunpowder.

When the platina-*mohr* prepared by means of zinc is moistened with alcohol, it becomes incandescent, and emits osmic acid; but if it be mixed with alcohol into a paste, and spread upon a watch-glass, nothing but acetic acid will be disengaged; affording an elegant means of diffusing the odor of vinegar in an apartment.

It is extensively used in this country and Britain, in the manufacture of acetic acid.

PLATINUM. A metal of a white color, exceedingly ductile, malleable, and difficult of fusion. It is the heaviest substance known, its specific gravity being 21.5. It undergoes no change from air or moisture, and is not attacked by any of the pure acids; it is dissolved by chlorine and nitromuriatic acid, and is oxydized at high temperatures by pure potassa and lithia. It is found to a small extent in Georgia, in the gold regions; it has not yet been met with in California. It exists in New Grenada, in Brazil, and in the Ural mountains of Russia. It is usually in small grains of a metallic lustre, associated or combined with palladium, rhodium, iridium, and osmium; and with copper, iron, lead, titanium, chromium, gold and silver; it is also usually mixed with alluvial sand. The particles are seldom so large as a small pea, but sometimes lumps have been found of the size of a hazel-nut to that of a pigeon's egg. In 1826, it was first discovered in a *vein*, associated with gold, by Boussingault, in the province of Atioquia, in South America. When a perfectly clean surface of platinum is presented to a mixture of hydrogen and oxygen gas, it has the extraordinary property of causing them to combine so as to form water, and often with such rapidity as to render the metal red hot: *spongy platinum*, as it is usually called, obtained by heating the ammonio-chloride of platinum, is most effective in producing this extraordinary result; and a jet of hydrogen directed upon it may be inflamed by the metal thus ignited, a property which has been applied to the construction of convenient instruments for procuring a light. The equivalent of platinum is about 98. It is precipitated from its nitro-muriatic solution by sal ammoniac, which throws it down in the form of a yellow powder, composed of bichloride of platinum and sal ammoniac.

It is generally found associated with iridium, osmium, rhodium, palladium, iron and copper. By far the greater part of the platinum of commerce comes from the Ural mountains. Only a limited portion of the whole is allowed by the Russian government to come into the market. Platinum is used as a coin metal in Russia, and the following is the mode by which it is obtained pure from the ore in St. Petersburgh:—

One part of the ore is put in open platina vessels, capable of containing from 6 to 8 lbs., along with 3 parts of muriatic acid at 25° B. and 1 part of nitric acid at 40°. Thirty of these vessels are placed upon a sand-bath covered with a glazed dome with movable panes, which is surmounted by a ventilating chimney to carry the vapors out of the laboratory. Heat is applied for eight or ten hours, till no more red vapors appear; a proof that the whole nitric acid is decomposed, though some of the muriatic remains. After settling, the supernatant liquid is decanted off into large cylindrical glass vessels, the residuum is washed, and the washing is also decanted off. A fresh quantity of nitro-muriatic acid is now poured upon the residuum. This treatment is repeated till the whole solid matter has eventually disappeared. The ore requires for solution from ten to fifteen times its weight of nitro-muriatic acid, according to the size of its grains.

The solutions thus made are all acid; a circumstance essential to prevent the iridium from precipitating with the platinum, by the water of ammonia, which is next added. The deposit being allowed to form, the mother-waters are poured off, the precipitate is washed with cold water, dried, and calcined in crucibles of platinum.

The mother-waters and the washings are afterwards treated separately. The first being concentrated to one-twelfth of their bulk in glass retorts, on cooling they let fall the iridium in the state of an ammoniacal chloride, constituting a dark-purple powder, occasionally crystallized in regular octahedrons. The washings are evaporated to dryness in porcelain vessels; the residuum is calcined and treated like fresh ore; but the platinum it affords needs a second purification.

For agglomerating the platinum, the spongy mass is pounded in bronze mortars; the powder is passed through a fine sieve, and put into a cylinder of the intended size of the ingot. The cylinder is fitted with a rammer, which is forced in by a coining press, till the powder be much condensed. It is then turned out of the mould, and baked 36 hours in a porcelain kiln, after which it may be readily forged, if it be pure, and may receive any desired form from the hammer. It contracts in volume from 1-6th to 1-5th during the calcination. The cost of the manufacture of platinum is fixed by the administration at 32 franks the Russian pound; but so great a sum is never expended upon it.

The salts of platinum are not much in use. The bichloride is the most common, and is made by digesting nitro-muriatic on platinum in slips; it is used in solution as a test for potash, as it precipitates the salts of that alkali as a yellow double chloride of platinum of potassium, which is insoluble in alcohol. It is also used in the coating of surfaces with metallic platinum. The solution of bichloride is washed over the surface, which is then heated until the acid element is driven off; the surface is then polished. Sometimes a solution of the double chloride of soda and platinum is used. Three immersions of the article to be coated suffice; after each immersion the surface is dried and polished with chalk.

Imitation of Platinum.—Melt together one pound of brass with ten ounces of zinc; but as brass is composed of copper and zinc, in the proportion of about three pounds of the former to one pound of the latter, equal parts of the copper and zinc will produce the same compound in imitation of platina.

PLOUGH. An implement drawn by horses and guided by a driver, by which the surface of the soil is cut into longitudinal slices, and successively raised up and turned over. The object of the operation is to expose a new surface to the action of the air, and to render it fit for receiving the seed, or for harrowing, or for other operations of agriculture. Ploughs are of two kinds; those without wheels, commonly called swing-ploughs, and those with one or more wheels, called wheel-ploughs. The essential parts which compose both kinds of ploughs are, the beam by which it is drawn; the stilts or handles by which the ploughman guides it, being two levers connected with the beam; the coulter fixed into the beam, by which the furrow-slice is cut; the share, also attached to the beam, by which the slice is raised up; and, finally, the mould-board, by which the slice is turned over. The most improved wheel-plough is the same implement, with a wheel attached to the beam, for the purpose of keeping the share at a uniform distance beneath the surface. The subsoil plough, the invention of Mr. Smith, of Deanston, in Stirling, Scotland, is the swing-plough of a somewhat stronger construction than that in common use, but without the coulter and the mould-board. The use of this implement is to follow the common plough, and loosen the subsoil at the bottom of the furrow without raising it to the surface. The most improved form of this implement contains a muzzle (the instrument by which it is drawn), so contrived as that the horses may walk on the firm soil. The use of the subsoil-plough is one of the greatest modern improvements that has been introduced into the culture of arable land. Draining-ploughs are of different kinds. The mole-plough, instead of a share and mould-board, has a small iron cylinder attached to the lower extremity of the coulter, and which, being drawn through grass land, leaves in its track a small opening, which has been compared to the underground track of a mole, and into which the water percolates from the surface through the narrow slit formed by the upper part of the coulter, and is thus carried off to an open drain. The other kinds of draining-ploughs cut out the soil, raise it to the surface, and turn it over in the manner of the common plow, thus leaving a deep furrow, which is commonly farther deepened and modified by the spade, and afterwards partially filled with stones, draining tiles, or other materials, through which water may find its way, and finally, covered with the surface soil. Draining-ploughs, though, in theory, promising a saving of manual labor, yet, in practice, are found inconvenient, from the number of horses required to work them. Their use is, therefore, generally confined to free, deep, loamy soils, with an even surface.

In no country is there a better test of the advancement of agriculture than in the condition of the ploughs, and the improvement in their shape. Within the tropics, but little attention is paid to the use of the plough, and in Cuba the plough used is of the rudest form: a pointed piece of iron, shaped like a wedge, attached to a wooden tongue, and drawn by a pair of oxen, without yokes; the beasts there bear the weight of their burden upon their heads (not necks), and pull by their foreheads, the rope being drawn tightly around the horns. Of course, the plough just described turns no row, but merely roots up the ground.

There are ploughs for almost every situation and soil, in addition to several varieties which are exclusively used for the subsoil. Some are for heavy lands, and some for light; some for stony, and some for land full of roots; while several are made expressly for breaking up the untilled prairies of the west. Some are fitted for deep, and some for shallow draining. There is a great economy in the use of many ploughs, and it is desirable that every good farm should be supplied with varieties of this useful implement.

There are upwards of fifty various kinds of ploughs, such as *cotton*, *rice*, and *sugar* ploughs, two and four-horse ploughs, some of which have clevies attached to them, thus enabling the off-horse in ploughing wet meadow to walk on the solid ground, instead of a miry fresh-ploughed furrow: they also answer for shallow ditching. There are double mould-board ploughs and subsoil ploughs, with wheel clevies and draft rod. One-horse ploughs, with single and double mould-board; the latter work excellently between the rows of root crops and corn, when not beyond 42 inches apart, as they turn the furrow both ways, thus doing the double work of a single mould-board.

The plough, which, previous to 1848, had been so varied in its construction as to form the basis of claims for between three and four hundred American patents, still continues to present slight modifications. But of the eleven applications patented during the year most are for minor points of invention. One of the most interesting of this class of implements is the combined plough, remarkable for its number of adjustments for the various purposes of ploughing and cultivating the soil. The instrument is susceptible of change from a combined plough into a cultivator, and with devices for several changes even as a cultivator. As a combined plough, it consists of a frame-work of wood for supporting the standards for the changeable reversible shares or teeth, the outline of which is of a rhomboidal shape; the bottom edges of which shares are horizontal, and the forward points of which are turned to the right or left, inward or outward, according to the direction in which the soil is to be thrown. A vertical cross section through the share gives the form of the letter S, so that, when running in one direction, it scrapes the soil up, and when reversed back side before, its operation is to smooth it down, answering the purpose of a roller, such as used for covering planted grain. The share part has an upside down adjustment to fasten it to the standard, so that when the bottom is worn out, the share part may be inverted, and used again for the same length of time. If used as a gang plough, it has an adjustable landside to be attached to each share, so as to guide the plough and prevent it from running to the right or left, as it might otherwise do. When the instrument is to be used as a cultivator for pulverizing the soil, the landsides being removed, the teeth or shares may be set, some inclining inward and some outward, so that the forward teeth may throw the dirt inward, for example, and the rear teeth throw it outward. When the teeth have been set to work as a cultivator, and it is required to use the instrument as a roller, or as a substitute for the harrow, for covering in or pressing down the grain, the tongue is reversed, and the instrument becomes a substitute for the roller. Although this instrument possesses a great variety of changes and adjustments, only a limited claim could be granted for it.

A minor improvement has been added to the plough for ploughing among corn; which consists of a common plough having a cross-beam fastened near the forward end of the beam, and two cultivator teeth projecting downward from the ends of the cross-beam, for the purpose of tearing up and loosening the soil. Between this cross-beam and the plough, and partly over the anterior part of the mould-board, and in a direction oblique to the line of the furrow, there is arranged a strip of wood or metal called a guard, the object of which is to prevent the large masses of earth thrown up by the plough from falling upon the young plants. This *furrow guard* is so elevated as to be above the ordinary level of a small furrow, and its chief merit seems to consist in its adaptation to ploughing among corn while the plants are so small as to be liable to be covered up by the ordinary plough, when used without such protection.

PLOUGHING. The act of turning over the soil by means of the plough. Trench ploughing is effected by the plough passing twice along the same furrow; the first time for the purpose of throwing the surface soil into the bottom of the furrow; and the second time for raising a furrow-slice from under that which had been already turned over, and raising it up, &c., turning it upon the first furrow-slice, by means of which the surface soil is entirely buried, and a stratum of subsoil laid over it: thus effecting in the field what trenching with the spade does in the garden. Trench ploughing can only be employed with advantage where the subsoil is naturally dry and of good quality, or where it has been rendered so by draining and subsoil ploughing; for bad subsoil brought to the surface would be unfit for receiving seeds or plants.

The alteration produced upon the capability of land, by ploughing, is very great: the tenacity of soils is broken up, the particles separated, drainage and aëration more perfect. The absorbent power of the clay is brought into action, and the gaseous matter furnished by the atmospheric dews and rain is more perfectly retained. As a consequence of a new surface of earth being brought up, the ammonia carbonic and nitric acids which exist in the air, are retained and kept for the future use of the crop. Manures, also, for the same reason, are better absorbed. Worms and insects are thrown out, are thereby exposed to the element, and destroyed in great number, which, if such did not occur, would infest the growing crop of next year, and perhaps completely ruin it.

The furrows of clay soils should be

turned over at an angle of 45°, and the depth of the furrow-slice should be two-thirds of its width: thus, a furrow 6 inches deep should be 9 inches wide, or if 8 inches deep, 12 inches wide. This allows the furrows to lie equally and evenly. If the subsoil be similar to the surface, or be not too light, ploughing can hardly be carried too deep—generally 12 inches, for the usual tillage crops, is a depth to which the plough may be gradually carried. For gardens it may be carried to 15 or 18 inches. Whatever is the depth of the surface soil, the plough ought to turn it up completely; and, what is beyond that, may be loosened by the subsoil plough. The *cultivator* is used very often in this country as a substitute for the plough. Even with the most recent improvement in this instrument, any quantity of land ploughed is a great tax on the strength of animals. Thus, a pair of horses may plough three-fourths of an acre of light soil per day, and one-half of stiff soil. If the furrow-slide is 9 inches, an acre is 11 miles of furrows, without turning, equal to another mile; for there are 6,272,640 square inches in an acre, and 77,440 squares of 9 inches in an acre, and this, by 7040, the number of 9 inches in a mile, goes 11 times. If the slide were 10 inches, the plough would travel 9·9 miles, and if 8 inches, 12·875 miles. Ploughing is, therefore, severe labor for men and horses. In spade culture, if a man turn over 7 inches each time, or 49 square inches, $\frac{6,272,640}{49}$ the amount is equal to 128,000 spades, to be turned in an acre.

PLUMBAGO, or GRAPHITE, is sometimes found in thin, irregular, six-sided tables; but more generally in scales, or compact. Specific gravity 2. It consists of carbon 96, and iron 4. Its most remarkable depository is at Borrowdale, in Cumberland, where it exists in a bed of trap. The chief employment of plumbago is in manufacturing pencils and crucibles; the latter particularly, for the mint. It is also used for giving a gloss to iron stoves and railings, and for diminishing friction. It is also used as a coating in electro-metallurgy.

It occurs crystallized in the limestone of Orange, co. N. Y., and Sussex, co. N. J., and exists in large fibrous masses near Roger's Rock, on L. George, N. Y.; but its only valuable locality in the United States is at Stourbridge, in Worcester, co. Mass., where it forms veins in gneiss about one foot wide. It was worked formerly by the French, was then neglected, and has recently been reopened.

PLUSH is a textile fabric, having a sort of velvet nap or shag upon one side. It is composed regularly of a woof of a single woollen thread, and a two-fold warp, the one, wool of two threads twisted, the other, goat's or camel's hair. There are also several sorts of plush made entirely of worsted. It is manufactured, like velvet, in a loom with three treadles; two of which separate and depress the woollen warp, and the third raises the hair-warp, whereupon the weaver, throwing the shuttle, passes the woof between the woollen and hair warp; afterwards, laying a brass broach or needle under that of the hair, he cuts it with a knife destined for that use, running its fine slender point along in the hollow of the guide-broach, to the end of a piece extended upon a table. Thus the surface of the plush receives its velvety appearance. This stuff is also made of cotton and silk.

POINT NET. (*See* LACE.)

POLISHING METALS. The workmen commence by preparing the surfaces of the articles; that is to say, it is of importance to remove all the marks left by the file, the turning tool, the scraper, &c., in order to render the surfaces uniform.

This preparation is effected on those metals, which are not very hard, by means of pumice-stone, either used in substance or reduced to powder and water; and when in powder applied upon felt, or upon slips of soft wood, covered with buffalo or chamois skin, if the surfaces be flat; or with pieces of soft wood properly shaped, so as to penetrate into the hollows, and act upon the raised parts. When the first coarse marks are thus removed, they then proceed to remove those left by the pumice-stone. In order to do this, they employ finely powdered pumice-stone, which they grind up with olive-oil, and employ it upon felt, or upon small pieces of soft wood, such as that of the willow or sallow. It is important, in these manipulations, to observe an important rule, which is never to proceed from one operation to another, before previously washing the pieces of work well with soap and water, by means of a brush, in order entirely to remove the pumice-stone, used with water, before employing it with oil, and likewise never to use those tools for succeeding operations, which had been used in preceding ones; each stage of the operation requiring particular tools, and which should be kept in closed boxes, in order to prevent the powders being diffused or scattered about when not in use.

After removing the marks left by the coarse pumice-stone and water, by means of finely-grounded pumice-stone and oil: to know which, we should wash it with soap and water, and dry it well with a linen cloth: we must then examine it with a lens or magnifying-glass, to see whether any scratches yet remain; if not we may proceed to the polishing. The softer metals are polished in different manners, according to their size and uses; the larger gold works are, however, generally burnished, but the smaller gold works in jewelry, &c., and those in brass for watch-work, are not burnished, but polished. The following are manipulations:—After having removed with oil-stone powder the marks of the file, &c. they smooth them with blue and grey stones, and plenty of water: there are two kinds of these stones, the one soft and the other hard: the first argillaceous schistus, the second kind schisto coticule; this serves to sharpen tools upon. The pieces of watch-work are always smoothened in this manner, until all the marks disappear, and which is known by washing them with soap and water.

They finally proceed to polishing with the tripoli from Venice, which is preferable to any other sort, and is either finely ground in water, or in olive-oil, according to the different cases, for pieces of gold work, or the larger kinds of jewelry articles, and until they perceive their surfaces are become perfectly brilliant; they then finish them with tripoli, reduced to an impalpable powder, and applied upon a very soft brush.

For polishing those pieces of watch-work which are not to be gilt; after smoothing them with grey or blue-stone and water, they polish them with rotten-stone well washed over, and consequently very fine, ground up with olive-oil, and finish them with dry rotten-stone. This rotten-stone is a kind of very light tripoli, but finer and more friable than the other sorts. It is found in England, and is highly esteemed for polishing; it is of an ashy-grey tint, and occurs in thin layers, upon the compact carbonate of lime, near Bakewell. The polishing of steel is not executed in the same manner as in polishing the softer metals; the steel is not polished until it has been hardened, and the harder it is the more brilliant will be its polish. The substances above indicated for polishing other metals are not powerful enough to attack a substance so hard as this. We must employ emery ground in oil, before used. Hardened steel is either polished flat, like glass, or cut into facets, like a diamond; consequently, the lapidary's mill is used. They commence by smoothing the work with rather coarse emery, then with finer emery, and finish with the finest. The smoothing being perfected, they polish it with English rouge, tritoxide of iron and oil, and finally finish it with putty of tin (peroxide of tin) and water; but if upon mills, or laps of zinc, then without the use of water. When the steel articles consist of raised and hollow work, they are smoothed and polished with the same substance; but the instruments are, as in the case of less harder metals, pieces of wood, properly shaped, and employed in the same manner. The finish at Sheffield is effected with the female hand.

Polishing Ivory, Bone, Horn, and Tortoise-shell. Ivory and bone, either plain or ornamented; and ivory or bone articles admit of being turned very smooth, or, when filed, may afterwards be scraped, so as to present a good surface. They may be polished by rubbing them first with fine glass paper, and then with a piece of wet linen cloth dipped in powdered pumice-stone; this will give a very fine surface, and the final polish may be produced by washed chalk, or fine whiting applied upon another piece of cloth wetted with soap-suds.

Horn and Tortoise-shell. A very perfect surface is given by scraping them; the scraper may be made of a razor-blade, the edge of which should be rubbed upon an oil-stone, holding the blade nearly upright all the while, so as to form an edge like that of a currier's knife; and which, like it, may be sharpened and improved by burnishing, at least as far as its hardness will permit. To prepare the work, when properly scraped for polishing, it is first to be rubbed with a buff, made of woollen cloth, perfectly free from grease. After the work has been made as smooth as possible by this means, it must be followed by another buff or bob, on which washed chalk or dry whiting is rubbed; the comb, or other article, is to be slightly moistened with vinegar, and the buff and whiting will produce a fine gloss, which may be completed by rubbing it with the palm of the hand, and a small portion of dry whiting or rotten-stone.

Polishing Iron, Brass, &c. A beautiful surface is produced upon cast-iron, steel, and brass-works, by means of emery sticks, and others coated with crocus. Mix drying linseed-oil, in the proportion of one-eighth part with glue, and coat the surfaces of pieces of soft yellow pine, fir, or deal, without turpentine or knots, which are about eight inches long, and five-eighths of an inch square, and nicely planed. Lay on a coat of thin glue, and when that is dry, another composed of glue mixed with the emery or crocus, and then instantly sift over the wet surface the emery or crocus in powder, by means of a sieve. Emery is employed of different degrees of fineness, and sticks thus coated with each may be used in succession, to smooth the work; and, lastly, sticks coated with glue and crocus are used to give the finishing polish. Such emery and crocus sticks are very durable, and are equally useful on works in the lathe, as well as upon flat surfaces; are superior to the glass or emery papers ordinarily used; and greatly to emery mixed with oil, and applied upon sticks in the common way.

Hindoo Polish. Powdered corundum with melt lac is used to polish all stones, first sprinkling them with water.

German Polish. The wood is prepared with pumice-stone rubbed flat, oiled, and then rubbed together till smooth. The only varnish then used is a solution of seed-lac or shell-lac in alcohol, the clearest grains of lac being for the lightest varnish. It is colored red with Brazil wood, and yellow by turmeric root. It is applied with a rubber of five pieces of linen; the varnish is laid on with a sponge, and when soaked, linseed-oil is added, and the whole gone over with a rubber.

POPLIN. Among the varieties of woven goods in which silk and worsted or silk and woollen are used in combination, poplin is one of the best and most esteemed. *Tabinet* is one form of the material, and Ireland has been distinguished for the excellence of its poplins and tabinets. The demand is now small, as other kinds of textile fabrics have lately been more in favor; but the rich Irish Poplins and Tabinets, though employing only a small number of persons in their manufacture, maintain their high character.

POPPY. *See* OPIUM.

PORPHYRY, is a compound rock, having a basis in which the other contemporaneous constituent parts are imbedded. The base is sometimes claystone, sometimes hornstone, sometimes compact feldspar, jade, pitchstone, pearlstone, and obsidian. The feldspar paste is most frequent. The imbedded parts are commonly feldspar and quartz; the former in more or less distinct crystals. There are porphyries of different ages. One variety is found graduating into granite and gneiss; but this does not possess the characteristics of the rock in the highest perfection; another is found in overlying strata, and unconformable to other rocks, which is the true porphyry. Its color is of the red or green, and, when polished, is valuable for ornamental work.

PORTLAND POWDER, once considered a specific for the gout, is made of equal parts powdered and mixed of the roots of gentian and birthwort, the tops and leaves of germander, ground pine and lesser centaury.

PORTLAND STONE. An oolitic formation found in Dorsetshire, England, used in building, but it is a stone which readily decays.

POTASH, or POTASSA. This substance was so named from being prepared for commercial purposes by evaporating in iron pots the lixivium of the ashes of wood fuel. In the crude state called potashes, it consists, therefore, of such constituents of burned vegetables as are very soluble in water, and fixed in the fire. The potash salts of plants which originally contained vegetable acids, will be converted into carbonates, the sulphates will become sulphites, sulphurets, or even carbonates, according to the manner of incineration; the nitrates will be changed into pure carbonates, while the muriates or chlorides will remain unaltered. Should quicklime be added to the solution of the ashes, a corresponding portion of caustic potassa will be introduced into the product, with more or less lime, according to the care taken in decanting off the clear ley for evaporation.

On this continent, where timber is in many places an incumbrance upon the soil, it is felled, piled up in pyramids, and burned, solely with a view to the manufacture of potashes. The ashes are put into wooden cisterns, having a plug at the bottom of one of the sides under a false bottom; a moderate quantity of water is then poured on the mass, and some quicklime is stirred in. After standing for a few hours, so as to take up the soluble matter, the clear liquor is drawn off, evaporated to dryness in iron pots, and finally fused at a red heat into compact masses, which are gray on the outside, and pink-colored within.

Pearlash is prepared by calcining potashes upon a reverberatory hearth, till the whole carbonaceous matter, and the greater part of the sulphur, be dissipated; then lixiviating the mass, in a cistern having a false bottom covered with straw, evaporating the clear ley to dryness in flat iron pans, and stirring it towards the end into white lumpy granulations.

The best pink Canadian potashes contain pretty uniformly 60 per cent. of absolute potassa; and the best pearlashes contain 50 per cent.; alkali in the former being nearly in a caustic state; in the latter, carbonated.

All kinds of vegetables do not yield the same proportion of potassa. The more succulent the plant, the more it affords, for it is only in the juices that the vegetable salts reside, which are converted by incineration into alkaline matter. Herbaceous weeds are more productive of potash than the gramniniverous species, or shrubs, and these than trees; and for a like reason, twigs and leaves are more productive than timber. But plants in all cases are richest in alkaline salts when they have arrived at maturity. The soil in which they grow also influences the quantity of saline matter.

The following TABLE exhibits the average product in potassa of several plants:—

In 1000 parts.	Potassa.
Pine of fir	0-45
Poplar	0-75
Trefoil	0-75
Beechwood	1-45
Oak	1-58
Boxwood	2-26
Willow	2-35
Elm and maple	3-90
Wheat straw	3-90
Barb of oak twigs	4-20
Thistles	5-00
Flax stems	5-00
Small rushes	5-08
Vine shoots	5-50
Barley straw	5-80
Dry beech bark	6-00
Fern	6-26
Large rush	7-22
Stalk of maize	17-50
Bastard chamomile (*Anthemis cotula*, L.)	19-60
Bean stalks	20-00
Sunflower stalks	20-00
Common nettle	25-03
Vetch plant	27-50
Thistles in full growth	35-37
Dry straw of wheat before earing	47-00
Wormwood	73-00
Fumitory	79-00

Stalks of tobacco, potatoes, chestnuts, chestnut husks, broom, heath, furze, tansy, sorrel, vine leaves, beet leaves, orach, and many other plants, abound in potash salts.

The purification of pearlash is founded upon the fact of its being more soluble in water than the neutral salts which debase it. Upon any given quantity of that substance, in an iron pot, let one and a half times its weight of water be poured, and let a gentle heat be applied for a short time. When the whole has again cooled, the bottom will be incrusted with the salts, while a solution of nearly pure carbonate of potash will be found floating above, which may be drawn off clear by a syphon. The salts may be afterwards thrown upon a filter of gravel. If this ley be diluted with 6 times its bulk of water mixed with as much slaked lime as there was pearlash employed, and the mixture be boiled for an hour, the potash will become caustic, by giving up its carbonic acid to the lime. If the clear settled lixivium be now syphoned off, and concentrated by boiling in a covered iron pan, till it assumes the appearance of oil, it will constitute the common caustic of the surgeon, the *potassa fuza* of the shops. But to obtain potassa chemically pure, recourse must be had to the bicarbonate, nitrate, or tartrate of potassa, salts which, when carefully crystallized, are exempt from any thing to render the potassa derived from them impure. The bicarbonate having been gently ignited in a silver basin, is to be dissolved in 6 times its weight of water, and the solution is to be boiled for an hour, along with one pound of slaked lime for every pound of the bicarbonate used. The whole must be left to settle without contact of air. The supernatant ley is to be drawn off by a syphon, and evaporated in an iron or silver vessel provided with a small orifice in its close cover for the escape of the steam, till it assumes, as above, the appearance of oil, or till it be nearly redhot. The fused potassa is now poured out upon a bright plate of iron, cut into pieces as soon as it concretes, and put up immediately in a bottle furnished with a well-ground stopper. It is hydrate of potassa, being composed of 1 atom of potassa 48, + 1 atom of water 9, = 57.

A pure carbonate of potassa may be also prepared by fusing pure nitre in an earthen crucible, and projecting charcoal into it by small bits at a time, till it ceases to cause deflagration. Or a mixture of 10 parts of nitre and 1 of charcoal may be deflagrated in small successive portions in a redhot deep crucible. When a mixture of 2 parts of tartrate of potassa, or crystals of tartar, and 1 of nitre, is deflagrated, pure carbonate of potassa remains mixed with charcoal, which by lixiviation, and the agency of quicklime, will afford a pure hydrate. Crystals of tartar calcined alone yield also a pure carbonate.

Caustic potassa may be crystallized; but in general it occurs as a white brittle substance of spec. grav. 1.708, which melts at a red heat, evaporates at a white heat, deliquesces into a liquid in the air, and attracts carbonic acid; is soluble in water and alcohol, forms soft soaps with fat oils, and soapy-looking compounds with resins and wax; dissolves sulphur, some metallic sulphurets, as those of antimony, arsenic, &c., as also silica, alumina, and certain other bases; and decomposes animal textures, as hair, wool, silk, horn, skin, &c. It should never be touched with the tongue or the fingers.

The only certain way of determining the quantity of free potassa in any solid or liquid, is from the quantity of a dilute acid of known strength which it can saturate.

The hydrate of potassa, or its ley, often contains a notable quantity of carbonate, the presence of which may be detected by lime water, and its amount be ascertained by the loss of weight which it suffers, when weighed portion of the ley is poured into a weighed portion of dilute sulphuric acid poised in the scale of a balance.

Carbonate of potassa is composed of 48 parts of base, and 22 of acid, according to most British authorities; or, in 100 parts, of 68-57 and 31-43; but according to Berzelius, of 68-09 and 31-91.

Carbonate of potassa, as it exists associated with carbon in calcined tartar, passes very readily into the *Bicarbonate*, on being moistened with water, and having a current of carbonic acid gas passed through it. The absorption takes place so rapidly, that the mass becomes hot, and therefore ought to be surrounded with cold water. The salt should then be dissolved in the smallest quantity of water at 120° F., filtered, and crystallized.

The exports of potash for the years 1847–48 was—in 1847, 618,000 dollars; in 1848, 466,477. The quantity in value which came to the Hudson River, on all the canals, was—in 1846, ashes, barrels, 46,812, value, 1,076,904; in 1847, ashes, barrels, 37,538, value, 1,135,288.

POTATO. The tubers of the *Solanum tuberosum.*—The potato, which is at present to be met with everywhere in Europe, and forms the principal part of the food of a large proportion of its inhabitants, was entirely unknown in that quarter of the world till the latter part of the 16th century. It is a native of America; but whether of both divisions of this continent is doubtful. Some authors affirm that it was first introduced into Europe by Sir John Hawkins, in 1545; others that it was introduced by Sir Francis Drake, in 1573; and others, again, that it was for the first time brought to England from Virginia by Sir Walter Raleigh, in 1586. But this discrepancy seems to have arisen from confounding the common or Virginian potato (the *Solanum tuberosum* of Linnæus) with the sweet potato (*Convolvulus battatus*). The latter was introduced into Europe long before the former, and it seems most probable that it was the species brought from New Grenada by Hawkins. Sweet potatoes require a warm climate, and do not succeed in England; they were. however, introduced there in considerable quantities, during the 16th century, from Spain and the Canaries, and were supposed to have some rather peculiar properties. The kissing comfits of Falstaff, and such like confections, were principally made of battatas and eringo roots. Potatoes were at first cultivated by a very few, and were looked upon as a great delicacy. In a manuscript account of the household expenses of Queen Anne, wife of James I., who died in 1618, and which is supposed to have been written in 1613, the purchase of a small quantity of potatoes is mentioned at the price of 2*s*. a pound. Previously, however, to 1684, they were raised only in the gardens of the nobility and gentry; but in that year they were planted for the first time, in the open fields in Lancashire—a county in which they have long been very extensively cultivated.

Potatoes, it is commonly thought, were not introduced into Ireland till 1610, when a small quantity was sent by Sir Walter Raleigh to be planted in a garden in his estate in the vicinity of Youghal. Their cultivation extended far more readily than in England; and have long furnished from three-fifths to four-fifths of the entire food of the people of Ireland!

The extension of the potato cultivation has been particularly rapid during the last forty years. The quantity that is now raised in Scotland is supposed to be from 10 to 12 times as great as the quantity raised in it at the end of the American war; and though the increase in

England has not been nearly so great as in Scotland, it has been greater than at any previous period of equal duration. The increase through Europe has been similar. Potatoes are now very largely cultivated in France, Italy, and Germany ; and, with the exception of the Irish, the Swiss have become their greatest consumers. They were introduced into India some sixty or seventy years ago; and are now successfully cultivated in Bengal, and have been introduced into the Madras provinces, Java, the Philippines, and China. But the common potato does not thrive within the tropics, unless it be raised at an elevation of 3000 or 4000 feet above the level of the sea, so that it can never come into very general use in these regions. This, however, is not the case with the sweet potato, which has also been introduced into tropical Asia; and with such success, that it already forms a considerable portion of the food of the people of Java, and some other countries. So rapid an extension of the taste for, and the cultivation of an exotic, has no parallel in the history of industry ; it has had, and will continue to have, the most powerful influence on the condition of mankind.

The sweet potato is the tuber of the *Convolvulus battatus*. It is a root of general growth, and much cultivated in the middle sections of the United States. Since the repeated failures and disease of the common potato, much attention has been turned to the raising this crop in New Jersey and Pennsylvania. They are generally planted in hills or drills on well manured land, and are fit for gathering when the vines are dead. There are numerous varieties of the sweet potato—as the white, red, yellow, &c. Fine crops are generally raised in the Southern States. The general average crop of South Carolina is 50 bushels per acre, though near Charleston, 100, and even 150 bushels have been raised. Similar crops are raised in Georgia and Alabama. In Louisiana 100 bushels are a fair crop. It is grown equally with the common potato in Kentucky and Tennessee, and its cultivation is extending in Ohio. Over the entire States its cultivation is extending. It is hardier than the common potato, and has not been subject to what has been called the potato rot.

Bryant, in his "What I saw in California," describes a root which he met with on the great prairie, and which he calls *prairie potato*, which he considers in many respects superior to the common potato, and which it might be useful to introduce into cultivation. It is not grown in Europe, for food.

Potatoes are not as much used in this country as in Europe, yet the crops raised over the whole country appear to be very great. Potatoes are grown more abundantly in Canada and the Northern States, than in the Middle and Southern States. The produce there is also greater, but the tubers are more subject to the rot. In Maine potatoes are raised largely for export. The estimate of the potato crop in 1848 over 32 States was equal to 114,475,000 bushels, of which the State of New York grew 27,000,000 bushels. The disease and failure of this crop of late years has been a great drawback to its more extensive cultivation. The crop varies from 50 to 200 bushels per acre.

According to Dr. Dobereiner, the following is the *chemical composition* of potatoes obtained from the seed.

	Potatoes from Albert.	From Krause.	From Greger.
Water..........	714.4	756.2	810.9
Starch..........	115.9	110.5	107.0
Fibrine........	70.9	52.5	50.0
Substances soluble in water..	98.8	80.8	82.1
	1000.0	1000.0	1000.0

The following analysis by Dobereiner, is given of a large sort grown in the year 1845.

Water	740.9
Starch..........................	120.0
Fibrine.........................	48.9
Albumen Gum	90.2
	1.0000

From other analyses, it appears that, of this valuable root, 72·6 parts in 100 are water, 15 starch, 7 fibre, or gluten, and 5·4 albumen, and mucilage. Two flour and 1 potatoes make excellent bread. The starch is superior to wheaten starch. With some gum tragacanth it is commonly sold for arrow-root, and, perhaps, is its equal.

In 100 lbs. of potatoes, only 25 parts are solid, or nutritive, while the remaining 75 consist of liquid. It contains, also, a dark acid substance, and it is highly important to get rid of this, which may be accomplished by repeated washings, after the root is grated. The nutritive parts of the potato consist—1, of flour and starch ; and 2, of fibre. These, when the potatoes are grated, can be separated by a common strainer. The flour, which will be accumulated at the bottom of the tub, must be repeatedly washed, to clear it of the acid substance with which it is impregnated.

It can be converted into a jelly, in the same manner as arrow-root. For that purpose, it must be moistened with cold water, then put into a bowl, and boiling water gradually poured on it, constantly stirring it with a spoon, for a few minutes, till the jelly is formed. It will be improved by a little salt, or a little sugar, before the boiling water is poured on it. A wholesome and nourishing food is thus produced, which, with the addition of a little milk is extremely palatable.

The quantity of flour, or starch, in a potato differs considerably, according to the sort, and the season. It varies from a fourth to a seventh part of the weight of the root. In regard to the fibrous part, it is a most valuable article of food, whether dried for horses, or boiled for cows and pigs.

POTATO STARCH may be roughly made thus: Put a pound and a quarter of potatoes, grated through a common tin bread grater, into a pan of water, and stir with a wooden spoon, and as soon as the pulpy matter has subsided, the discolored water is poured off, and clean water added, and the mass again stirred up. When it has settled a second time, the water is poured off by a gentle inclination of the vessel, and the process repeated till the water passed off is colorless. Three washings are sufficient. The residue is turned out of the pan, and dried in the air, and it produces four ounces of very fine white flour, or one-fifth of the original weight of the potatoes. It may be used as a substitute for arrow-root, for years. A bread-grater is the only instrument necessary.

Potato flour, and Arrow-root flour.—Potato flour may be known from arrow-root flour, by rubbing a little of it between the finger and thumb, when it will be observed that the potato flour is softer to the *touch*, and more shining to the *sight*, than arrow-root.

Size from Potatoes.—Starch of potatoes, quite fresh, and washed only once, may be employed to make size; which, mixed with chalk, and diluted in a little water, forms a very beautiful and good white for ceilings. This size has no smell, and is more durable.

Potato starch is manufactured extensively in this country, in Maine. The following account of a starch manufactory in Michigan, at Almont, Lopez county, will illustrate the mode in which it is usually made here. It is probably the largest establishment of the kind in the United States, and is owned by a gentleman who is also interested, it is said, in two others in Vermont. It is quoted from the Patent Office Report.

"The factory is 214 feet long and 40 wide, including an L. The main building is 184 feet long, 14 of which are used for an engine room, and is two stories high. The lower part has 64 tubs, holding about 600 gallons each, giving a total of 28,400 gallons. The L part is 80 feet long by 40, of brick, one and a half stories high, for a potato bin. Loaded teams drive up a platform into the second story, and following a circle, 18 teams can unload at a time, through a trap door over the bin, which is calculated to hold 40,000 bushels. One hundred and thirty loads have been received in a day, making a total of 4000 bushels.

"In the second story of the principal building is an oven 100 feet long by 18 wide, for drying the starch; or rather, I should say, an oven of 200 feet by 9, as there is a division in the centre, with doors some ten feet apart. In the oven there are sets of pans, one above the other, which can be turned at pleasure. It is heated from the steam works, and conductors of heat are carried in tin pipes all over the building.

"The potatoes are shovelled from the bin into a hopper, where there is water constantly running into it, and where they are as thoroughly washed by machinery as a cook could do it for your dinner. Then, by the action of the machinery, they are separated from the dirt, stones, and sticks, and pass on to two cylinder graters, at the rate of 100 bushels an hour. From the graters, by the action of the machinery, they go into the sieve, that separates the starch from the potato. The pulp then passes into four large cisterns, and there again machinery pumps it into the 64 large tubs or cisterns, before alluded to, for settling. Then the water is drawn off, and the starch, by a forcing pump, is carried into the second story, and, when settled, put into the oven I have before spoken of, which is calculated to bake a day's work, being the starch from 1000 bushels or 60,000 lbs. of potatoes. The starch is packed in casks and shipped east. The cost of the factory is $12,000.

"Considerable starch was made in the season of 1846, but the rotting of some 30,000 bushels that fall curtailed the quantity anticipated. This large quantity of the raw material was thrown away. It served to feed many cattle and hogs of the neighborhood for some months. The pulp remaining as worthless is used in fattening hogs, which the proprietor has in a yard adjoining.

"The factory price for potatoes is ten cents a bushel. The owner has contracted with various farmers to the amount of 400 acres. The average number of bushels raised in the year 1846 on an acre, was 275. Allowing the same this year, it will amount to over 100,000 bushels; but this is not half the quantity wanted. Farmers are unwilling to contract, fearing the rot. Present indications are good for the crop. All varieties are used—even the Rohan.

"It takes the fall and winter to use up the potatoes; then wheat and corn are used for the same purpose. The quantity made from the potato per year will not be far from 1,000,000 lbs. or 500 tons. It sells for $5 a hundred in New York."

POTSTONE. A tough variety of steatite, sometimes manufactured into culinary vessels.

POTTERY, PORCELAIN. In reference to chemical constitution, there are only two genera of baked stoneware. The first consists of a fusible earthy mixture, along with an infusible, which when combined are susceptible of becoming semi-vitrified and translucent in the kiln. This constitutes porcelain or china-ware; which is either hard and genuine, or tender and spurious, according to the quality and quantity of the fusible ingredient. The second kind consists of an infusible mixture of earths, which is refractory in the kiln, and continues opaque. This is pottery, properly so called; but it comprehends several sub species, which graduate into each other by imperceptible shades of difference. To this head belong earthenware, stoneware, flintware, *fayence*, delftware, iron-stone, china, &c.

The earliest attempts to make a compact stoneware, with a painted glaze, seem to have originated with the Arabians in Spain, about the 9th century, and to have passed thence into Majorca, in which island they were carried on with no little success. In the 14th century, these articles, and the art of imitating them were highly prized by the Italians, under the name of Majolica, and *porcelana*, from the Portuguese word for a cup. The first fabric of stoneware possessed by them was erected at Fayenza, in the ecclesiastical state, whence the French term *fayence* is derived. The body of the ware was usually a red clay, and the glaze was opaque, being formed of the oxydes of lead and tin, along with potash and sand. Bernhard de Palissy, about the middle of the 16th century, manufactured the first white *fayence*, at Saintes, in France; and not long afterwards the Dutch produced a similar article, of substantial make, under the name of delftware, and delft *porcelain*, but destitute of those graceful forms and paintings for which the ware of Fayenza was distinguished. Common fayence may be, therefore, regarded as a strong, well-burned, but rather coarse-grained kind of stoneware.

It was in the 17th century that a small work for making earthenware of a coarse description, coated with a common lead glaze, was formed at Burslem, in Staffordshire, which may be considered as the germ of the vast potteries now established in that county. The manufacture was improved about the year 1690, by two Dutchmen, the brothers Elers, who intoroduced the mode of glazing ware by the vapor of salt, which they threw by handfuls at a certain period among the ignited goods in the kiln. But these were rude, unscientific, and desultory efforts. It is to the late Josiah Wedgewood, Esq., of England, that the world at large is mainly indebted for the great modern advancement of the *ceramic* art.

This country contains all the materials for establishing a perfect manufacture; but as yet little has been done except in the production of coarse articles. The better kind of pottery, is made of an artificial mixture of alumina and silica; the former obtained in the form of a fine clay, from Devonshire in England, chiefly; and the latter consisting of chert or flint, which is heated red-hot, quenched in water, and then reduced to powder. Each material, carefully sifted, is diffused through water, mixed by measure, and brought to a due consistency by evaporation: it is then highly plastic, and formed upon the potter's wheel and lathe into various circular vessels, or moulded into other forms, which, after having been dried in a warm room, are inclosed in baked clay cases resembling bandboxes, and called *seggars*; these are ranged in the kiln so as nearly to fill it, leaving only space enough for the fuel: here the ware is kept red-hot for a considerable time, and thus brought to the state of *biscuit*. This is afterwards glazed, which is done by dipping the biscuit-ware into a tub containing a mixture of about 60 parts of litharge, 10 of clay, and 20 of ground flint, diffused in water, to a creamy consistence; and when taken out enough adheres to the piece to give an uniform glazing when again heated. The pieces are then again packed up in the seggars, with small bits of pottery interposed between each, and fired in a kiln as before. The glazing mixture fuses at a very moderate heat, and gives an uniform glossy coating, which finishes the process when it is intended for common white ware.

The patterns upon ordinary porcelain, which are chiefly in blue, in consequence of the facility of applying cobalt, are generally first printed off upon paper, which is attached to the plate or other article while in the state of biscuit; the color adheres permanently to the surface when heat is properly applied: other mineral colors, such as the oxides of chrome and manganese, are also occasionally employed in the same way.

The manufacture of porcelain is a more refined branch of art; the materials are selected with the greatest caution, it being necessary that the compound should remain perfectly white after exposure to heat; it is also required that it should endure a very high temperature without fusing, and at the same time acquire a semivitreous texture, and a peculiar degree of translucency and toughness. These qualities are united in some of the oriental porcelain, or *China*, and in some of the old Dresden; but they are rarely found coexistent in that of modern European manufacture. Some of the French and English porcelain, especially that made at Sevres and Worcester, is extremely white, and duly translucent; but it is more apt to crack by sudden changes of temperature; more brittle, and consequently requires to be formed into thicker and heavier vessels; and more fusible than the finest porcelains of Japan and China.

The colors employed in painting porcelain are the same metallic oxides used for coloring glass, and in all the more delicate patterns they are laid on with a camel-hair pencil, and generally previously mixed with a little oil of turpentine. Where several colors are used, they often require various temperatures for their perfection; in which case those that bear the highest heat are first applied, and subsequently those which are brought out at lower temperatures. This art of painting on porcelain, or *in enamel*, is of the most delicate description: much experience and skill are required in it, and with every care there are frequent failures; hence it is attended with considerable expense. The gilding of porcelain is generally performed by applying finely divided gold mixed with gum-water and borax; upon the application of heat the gum burns off, and the borax vitrifying upon the surface causes the gold firmly to adhere; it is afterwards burnished.

In the manufacture of various kinds of pottery employed in the chemical laboratory, and especially in regard to *crucibles*, many difficulties occur; and many requisites are necessary, which cannot be united in the same vessel. To the late Mr. Wedgewood we are indebted for vast improvements in this as well as in other branches of the art. Crucibles composed of one part of pure clay mixed with about three parts of coarse and pure sand, slowly dried and annealed, resist a very high temperature without fusion, and generally retain metallic substances; but where the metals are suffered to oxidize, there are few which do not act upon any earthen vessel, and some cause its rapid fusion, as the oxides of lead, bismuth, &c. Where saline fluxes are used, the best crucibles will always suffer; but platinum may often be employed in these cases, and the chemist is thus enabled to combat many difficulties which were nearly insurmountable before this metal was thus applied. Whenever silica and alumina are blended as in the mixture of clay and sand, the compound softens, and the vessel loses its shape when exposed to a long continued white heat, and this is the case with the *Hessian* crucibles: consequently, the most refractory of all vessels are those made entirely of clay, coarsely-powdered burned clay being used as a substitute for the sand. Such a compound resists the action of saline fluxes longer than any other, and is therefore used for the pots in glass furnaces. A Hessian crucible lined with purer clay is rendered much more retentive; and a thin china cup, or other dense porcelain, resists the action of saline matters in fusion for a considerable time. Plumbago is a very good material for crucibles, and applicable to many purposes; when mixed with clay it forms a very difficultly fusible compound, and is protected from the action of the air at high temperatures: it is well calculated for small table furnaces.

There are three kind of glazes in general use—one for the common pipe clay ware, another for the finer kind, and a third for the ornamental kind. The common glaze is composed of fifty-three parts white lead, sixteen parts Cornish stone, thirty-six of ground flints, four of flint glass. These compositions are ground with water into a thin paste. Another is twenty parts of flint glass, six of flints, two of nitre, and one of borax. This is mixed together, and twenty parts of it are ground with twenty-six parts of feldspar, twenty of white lead, six of ground flint, four of chalk, nine of oxide of tin and a small quantity of the oxide of cobalt.

Another glaze consists of twenty parts of flint glass, six of flints, two of nitre, one of borax. These must be calcined together, and to twelve parts of it add forty parts of white lead, thirty-six of feldspar, eight of flints, six of flint glass, then grind the whole together into a paste. These substances make a glaze which is not easily acted upon by vegetable acids, and is very hard. The oxide of tin and borax is said to produce a good common glaze, not dangerous like lead for cooking vessels. In glazing earthenware the smallest possible quantity of lead should be used, but a glaze can be made of ground glass and borax to answer any purpose, for what is a glaze but a glass surface?

POULTRY. Different kinds of birds reared for the production of eggs, feathers, and for the use of their bodies as animal food. The domestic poultry in common use in Britain are the common domestic fowls, or cock and hen, the turkey, the duck, and the goose: to which may be added, as occasionally reared, the guinea fowl and the peacock. The most generally useful kind of poultry is the common domestic fowl, which, though a native of India, accompanies man through all climates, but which is only productive of abundance of eggs when well fed and warmly lodged. Hence, all poultry-houses, when not built adjoining an apartment in which fire is kept, or over a stable or cow-house, where they might benefit by the heat generated by the larger animals, ought to be furnished with flues, or some other means of generating heat artificially during winter and spring. Without some mode of effecting this, poultry will seldom produce abundance of eggs in cold weather, particularly in the colder parts of Britain. Hence, in Scotland, the common hen roosts in the same room that the cottager lives in; and the poultry-house of the small farmer is a loft either over his kitchen, or over his cow-house. In the management of poultry it is not sufficient to supply abundance of food and warmth, but it is equally necessary that they have ample space for exercise. This space should always contain living plants of various kinds, and some gravelly or sandy soil; because worms, snails, and insects, as well as occasionally grass and herbage, form a part of the food of poultry; and sand or gravel is swallowed by them for the purpose of promoting digestion. Hence, no healthy poultry can ever be reared in towns, however much the natural food may be imitated by the supply of animal matters, herbage, and sand: the want of exercise in poultry so circumstanced will soon become evident from the appearance of the fowls, and from the soft shell of their eggs, in consequence of the animal functions not being efficiently performed.

In the management of these animals it must be remembered, cold exercises a constant and determinate action on the lungs. The effect of this action is the more rapid and more severe the younger the animal is. When cold does not cause acute, and speedily fatal inflammation of the lungs, it produces a chronic inflammation, which is pulmonary consumption. Heat always prevents the attack, and, when it has taken place, suspends its progress, and even sometimes arrests it entirely, and effects a complete cure. Pulmonary consumption is never, in any stage, contagious; and fowls affected with that disease, are not only all day long, with the healthy fowls, but at night roosted in the same places, without communicating their disease to them. Lastly, the action of too-long confined air exposes these animals to abscesses of the cornea, and inflammation of the ball of the eye; and these abscesses and inflammations are also caused by cold, especially with moisture.

Breeding Poultry.—The houses for this purpose may be built either of brick or stone, one story high, with wooden roofs, and must be heated by cast-iron steam-pipes. Their ceilings and walls must be finished with Roman cement. Each house is to be divided into four compartments,—the first for hatching and rearing chickens; the second for breeding turkeys; the third for ducks; and the fourth for geese. A furnace is built at one end, with a steam boiler to hold 50 gallons of water, which will heat a house 80 feet in length. The first two compartments must have the steam-pipes pass around both rooms at the bottom of the walls, for hatching chicken and turkey eggs, and they must pass once around the other two rooms, ducks and geese requiring less heat. The boiler must be also so constructed as to steam potatoes, parsnips, carrots, and herbs; which, when cooked and mixed with milk, barley, oats, or peas, meal, or flour, produce the finest chickens, and other poultry.

To make the hens lay all through the winter, mix powdered oyster-shells and slate, or decomposed schistus with their food. The lime in the oyster shells is necessary to form the shells of the eggs, and the slate improves their quality and flavor.

The following statistics on poultry and eggs drawn from the Patent Office Reports for 1847 and 1848 have some interest. It is stated that a bushel of corn will last twice as long for hens as a bushel of buckwheat, but the latter will make hens lay eggs more than any other grain, and the profit overbalance the cost. The number of eggs sent to market and consumed is very great. In the year 1846 it is said that 3,000,000 were packed and sent from Cincinnati in the spring. A single canal boat is noticed in a Rochester paper as on her way to Albany with 239 barrels of eggs, each barrel containing 90 dozen, which would thus give 258,120 dozen eggs. In France it is stated that 7,250,000,000 eggs are annually used, of which Paris consumes about 120,000,000. The importation of eggs from France by England amounted in 1838 in value to nearly $1,000,000, and the annual average amount is estimated at 100,000,000 of eggs. The amount of money invested in poultry in England is supposed to be not short of £8,000,000.

In Bixio's Journal d'Agriculture Pratique et Jardinage for April, 1848, we find a statement of the poultry and eggs of France alluding to actual statistics, he says: We have found 190,000 fowls for 85,685 inhabitants; and these 190,000 fowls give annually a product of 14,400,000 eggs, or 166 eggs to a person a year. Extending this calculation to the whole of France, he says: We find that the proportion of population to the number of fowls is that of 1 to 440. Now the population of France, according to the last census, was 34,230,178 inhabitants, and thus it will follow that, in the actual state of affairs, France feeds, by methods evidently defective, 47,938,628 fowls, which at 120 eggs each for a year, will give 5,752,635,360 eggs, which, at 4 francs per 100, is equal to 230,100,414 francs, equal to $46,021,082 80, (above forty-six millions of dollars, allowing 20 cents to the franc.) Adding the excess of 30 eggs per fowl as the result of artificial heat, there would be 150 eggs per fowl, (12 fowls, placed in a little court without any other heat than from that of manure, laid each 153 eggs, on an average, in 1846;) this would give a general total of 8,396,931,400 eggs, of the value of 287,631,768 francs more, (equal to 27,000,000 of dollars.)

We have heretofore adverted to the vast number of eggs consumed in our country. We find a variety of estimates; and it is evident that in many sections of the country both the amount of fowl raised and eggs consumed is very much larger than in others. In one day, from Cincinnati, Ohio, it is stated in one of the public journals, there were shipped 500 barrels containing 47,000 dozen of eggs. In some of the States, the poultry business appears to be much on the increase. In the state of New York, the opening of the Erie Railroad has had the effect of increasing the production of poultry and eggs to an incredible extent—a new market being found in the middle counties of this state, to supply the wants of half a million of people in this city.

POWER-LOOM. (*See* WEAVING.)

PNEUMATIC TROUGH. This is an apparatus for collecting and examining aëriform bodies, originally invented by Dr. Priestley. Wine and beer glasses of various sizes; apothecaries' phials; cleaned oil flasks, with glass and tin tubes of various dimensions; old gun-barrels; tobacco-pipes; an argand and a spirit-lamp, with a common fire and bellows, offer inexhaustible resources to a person indued with the faculty of contrivance; especially if he can seal and bend a glass tube over a lamp.

For the collection of gases, sparingly soluble in water, a white earthenware foot-bath, or a small washing-tub, may be employed. In this a shelf should be fixed. A glass, or metallic tube, proceeding from the vessel containing the substances from which the aëriform fluid is emitted, may then be laid under the edge of the jar, which, for this purpose, is permitted to project a little over the shelf; the gas will then rise into it in bubbles, and gradually displace the water. A gas may also be readily transferred from one vessel to another, by carefully reclining the glass which contains it under the edge of another filled with water, and projecting over the shelf; and they may likewise be removed from the bath, and transported from one place to another, by placing them in shallow vessels or saucers, and surrounding them with about an inch of water.

PRASE. Green quartz: the color is due to actynolite.

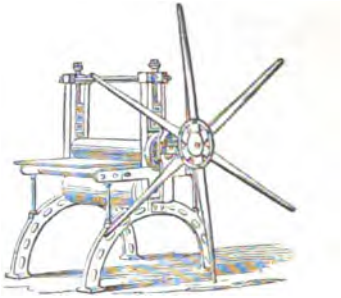
PRECIPITATE. A result of chemical decomposition, in which a substance is *thrown* down in a solid and finely-divided state out of a liquid.

PREHNITE. A mineral of a green color, one of the zeolites, called after M. Prehn.

PRESS. 1. An instrument or machine of iron or wood by which any body is squeezed, crushed, or forced into a more compact form; as, a *wine-press*, *cider-press*, or *cheese-press*. Any of the mechanical powers may be used for this purpose, and also the hydrostatic pressure of water. In the ordinary presses, the screw is employed as the power. *Hydrostatic press.*) *See* BRAMAH'S PRESS.) 2. A machine for printing; a printing press. Great improvements have been lately made in the construction of *presses*. (*See* PRINTING PRESS.)

Press for compressing Flour or Meal into Casks. Every barrel ought to be of the size to contain 196 lbs. of meal or flour, when compressed. An empty barrel, with a false one of the same size (that is, one without the top and bottom), placed above it, are first put upon the scales. The tare is made; and the opposite end of the balance is charged with a weight of 196 lbs. Meal to that weight is then put into the two barrels standing in this position, as, in its uncompressed state, one barrel could not hold this quantity of meal. The barrels are then placed under the press, where a rammer, exactly fitting the barrel, is made to descend upon them; the shaft of the rammer mounts and descends between two muffling-boards, which serve to guide it. It is furnished with two small beams, which are fixed in a sort of pivot, and which form the extremity of a large lever. When this lever is lowered, it causes the rammer to descend upon the meal, and a sufficient degree of pressure is thus produced. But, should it be required to augment the power of the lever, this can be done by applying another lever to assist in working the large lever. When the pressure is finished the lever is raised, and the false barrel, which is now empty, is removed.

Copper-plate, or Rolling-Press. The rolling-press, which is employed in nearly every species of copper-plate printing, is divided into two parts, the body and the carriage. The body consists of two wooden cheeks, placed perpendicularly on a stand or foot, which sustains the whole press. From the foot, likewise, rise four other perpendicular pieces, joined by cross or horizontal ones, which serve to sustain a smooth even plank or table, about four feet and a half long, two feet and a half broad, and an inch and a half thick. Into the cheeks go two wooden cylinders or rollers, about six inches in diameter, borne up at each end by the cheeks, whose ends, which are lessened to about two inches diameter, and called trunnions, turn in the cheeks about two pieces of wood in form of half moons, lined with polished iron to facilitate their motion. Lastly, to one of the trunnions of the upper roller is fastened a cross, consisting of two levers, or pieces of wood, traversing each other, the arms of which cross serve instead of the bar or handle of the letter-press, by turning the upper roller, and, when the plank is between the two rollers, giving the same motion to the under one, by drawing the plank forward and backward. The ink usually employed is a composition made of the stones of peaches and apricots, the bones of sheep, and ivory, all well burnt, and called *Frankfort Black*, mixed with nut-oil that has been well boiled; the two being ground together on a marble slab, in the same manner as painters grind their colors.



A small quantity of this ink is taken on a rubber, made of linen rags, strongly bound about each other, and then smeared over the whole face of the plate, as it lies on a grate over a charcoal fire. The plate being sufficiently inked, it is wiped over with a dirty rag, then with the palm of the left hand, then with that of the right; and to dry the hand, and forward the wiping, it is rubbed, from time to time, on whiting. ¶In wiping the plate perfectly clean, but without taking the ink out of the engraving, consists the skill of the workman. The plate, thus prepared, is laid on the plank of the press, and over the plate is laid the paper, well moistened to receive the impression; and over the paper two or three folds of flannel. The arms of the cross are then pulled, and the plate, with its furniture, is passed through between the collars, which, pinching very strongly, press the moistened paper into the strokes of the engraving, and it absorbs the ink from them.

Dick's Anti-Friction Press. Mr. David Dick's patented press, adapted for pressing cotton, punching, straightening railroad iron, embossing, and for every purpose of pressing. It is compact, and presents a most important arrangement of mechanical powers, to avoid friction. The great principle of this invention is the saving and centralizing of the power, by directing the power which is applied through a line of contact points. In all machinery constructed to gain power, by losing time, to use common terms, the loss by friction is very great, such as blocks and tackle, and other machinery, screw, &c., where the power is transmitted over a great extent of surface. In machinery for lifting or pressing, 100 lbs. passing through two feet space, will lift 200 lbs. through one foot of space, and so on in the same ratio, saving the friction, which is the great evil of all complicated machinery. This great drawback (friction) on power is removed, to a great extent, in Mr. Dick's press.

All the sectors are formed alike, but reversed in position—the upper and lower. There are two partial rotating cams, and two cog-wheels on the axle. This axle is allowed to move slightly up in its bearings. There is a pinion on a fixed axis, which is operated by the crank handle. A pinion and lever are employed, as required, on each side. There are sectors (four), one on each side of the cams; the lower ones are in a reverse position, viz., resting on their apex. The axle of the lower cam rests on curved surfaces of the lower sectors, and the axle of the upper cam presses on the curves of the upper sectors. The axle of the upper cam moves upward in its side bearings, and the upper sectors are pressed upward, pushing up the plate or frame, which moves upward in the guide slots. The upper sectors move in one direction, while the lower ones move in the contrary direction, bringing their curves to act most effectually, balancing all the motions, and acting in right lines through *points* of contact, produced by the contact of the curved surfaces of the axles, cams, and sectors, consequently the amount of friction is very small.

PRINTING is the multiplication of copies by movable types. It superseded the once extensive business of copying. It was a mere extension of the art of coining and seal engraving, on which letters were reversed like types, but the impressions were taken in wax or metal. The first printing pages were blocks, like broad seals, cut in wood, and stamped on paper, which last was taught by card-making, cards being invented about half a century before, and the impressions made with ink and blocks.

The history of its origin is enveloped in mystery; and this art, which commemorates all other inventions, which hands down to posterity every important event, which immortalizes the actions of the great, and which, above all, extends and diffuses the Word of God to all mankind; this very art has left its own origin in obscurity, and has given employment to the studies and researches of the most learned men in Europe, to determine to whom the honor of the invention is due.

According to Du Halde and the missionaries, the art of printing from engraved blocks of wood was practised in China nearly fifty years before the Christian era; and from the early commercial intercourse of the Venetians with that country, there is reason to believe that the knowledge of the art, and of its application to the multiplying of books was derived from thence; for Venice is the first place in Europe of which we have any account in which it is practised, as appears by the decree above mentioned, which is the most ancient document in existence respecting printing; but the date of this application of the art, or the place where it was first practised, it is impossible to determine. From that decree and the existence of the print of St. Christopher, it would seem that it had been long applied to the production of playing-cards, and of religious subjects, and when it was extended to books, they were printed by the Chinese method, still in use, each page being engraved on a block of wood: and if this plan was followed, as most probably it was, from its being the most correct—of fastening a page of manuscript on the face of the block and engraving from that, instead of drawing the characters on the wood—it would at once account for the diversity of characters found in the block books, which varied with the different handwritings of the scribes, and has completely puzzled the learned, who endeavor to ascertain the printer by comparing the characters with some other work.

About the year 1450, the great and accumulating expense of engraving blocks for each separate work of the increasing number of books produced by means of printing, led to the important improvement of the art of casting separate metal types, and substituting them for the wooden blocks previously used. This formed a new epoch in the art, and is now termed, erroneously, the origin of printing. After a lapse of many years, several cities claimed the honor of this invention, but time has reduced these claims to two—Haarlem and Mentz.

Many of the manuscripts of the 14th and 15th centuries were written in a beautiful manner, and embellished by borders round the pages, and by the large letters at the commencements of chapters being drawn and colored with brilliant colors, heightened with burnished gold, and finished with taste, delicacy, and great ability, so as to produce a most splendid effect. These were called illuminated manuscripts. On the first production of books by the process of printing, these ornamental letters were left blank, and both these letters and borders were finished by hand in the usual maner, which gave to the book a perfect resemblance to a manuscript, of which it became, by these means, a complete facsimile. This is the case with the Mentz Bible by Fust and Gutenberg. The first printers soon began to print these large ornamented letters, the letter itself being in some instances red and the ornamental part blue, in others the letter is blue and the ornamental part red; and these were afterwards finished by hand, as is apparent in the Psalter of 1457, printed by Fust and Schoeffer, who also showed great ingenuity and skill in the large letter B in the same book, which is printed with red ink, and the ornamental part, consisting of a flourished line, as if it had been drawn with a pen, extending from the top to the bottom of the folio page, with blue ink.

The means in use among the Chinese for producing an impression of letters appears to be nearly the same with those invented in the infancy of the art. Blocks of hard wood, or masses of metal forming a kind of stereotype, are printed from, by a simple and expeditious process, and solely by manual labor, as presses for the purpose are entirely unknown. The Canton Gazette, a kind of court journal of appointments, arrivals, and departures, is one of the few publications which are printed from movable types. The blocks which are mostly used for engraving these stereotypes upon, are made of hard and well-seasoned wood, divided into slabs, in the direction of the grain. The subject to be engraved is carefully written or drawn on thin paper, and pasted reversed upon the board; the wood is then cut from around the characters, and the letters remain in low relief. Much care is used in adjusting the written pattern, as it is not possible to rectify a mistake on copper or other metal. The cost of engraving depends entirely on the size and delicacy of the letter, the price increasing in proportion to the smallness of the type. The equipments of a printer are very simple and cheap, and the operations less complicated than almost any other mechanical process. The board or slab of wood is placed on a table before the workman, and a pile of dry paper, cut to the proper size, at his side, when, with a rude bamboo brush, a coating of liquid Indian ink is put upon it; a sheet of paper is then placed on the top, and the impression completed by rubbing it over once or twice with a kind of vegetable fibre: the sheet is then lifted off, and the process repeated with the next.

In the actual business of a printing-office, the first operation, called composing, is begun by the compositor laying the letter, called types (*see* TYPES), into as many cases as may be judged expedient in the first instance (*see* CASE), laying the italic in cases distinct from the roman, each letter or sort in the box appropriated to it: having done this with one fount, he will put the cases into the case rack, and proceed with another fount, till the whole of the letter is laid; he will put the superfluous sorts either into a fount case or into coffins; and he will then be ready to take copy.

The compositor having taken copy, and received directions concerning the measure, the length of the page, any peculiarity in the spelling of particular words, the use of capital letters, the punctuation, the words that are to be in italic or small capitals, and any other directions that may be deemed necessary, proceeds to make his measure, and cut a composing rule; he then begins to compose, letter by letter, till he has formed a word; he separates this from the following word by a space, and so continues till he has composed a line; he then justifies this line by increasing the space between the words, or lessening it, according to circumstances, so that the line shall be tolerably tight in the composing stick; and thus proceeds till he has completed a page; after having set the head line and direction line with the signature, he ties a page-cord round it to preserve it from falling asunder, puts it on a page-paper, and places it on the bottom of his frame; and thus continues till he has composed a sheet.

It may be necessary to state that every line is of the same length, whether the types fill it out or not; the last line of a paragraph, lines of poetry, and short lines of any other description, are filled up with quadrats to the proper length, in order that they may be secured from derangement by being wedged up in the chase; which is termed locking-up.

The pages are then taken to the imposing stone, and arranged in the proper order; the page-papers removed; a chase is then placed over them, furniture put about them, and the pagecords taken away; proper quoins are then selected, and the form is locked up. It is then taken to a press, and one impression is printed; this is styled the first proof, which is folded and taken to the reader with the copy; a boy reads the copy to him, while he examines the proof and marks the errors of the compositor, and puts a query to any doubtful matter for the author's consideration; the proof is then returned to the compositor, who corrects the errors and mistakes, and a second impression is printed with more care and generally on better paper; this is styled a clean proof; it is examined by the first proof to see that the errors of workmanship are corrected, which is termed revising, and then sent out with the copy to the author; he makes what alterations and corrections he may think necessary; these are corrected by the compositor; another impression is printed, revised, and read finally, and with care, for press: the margin is then adjusted; and the corrections being carefully made, it is taken to the press to be printed off.

In the mean time, after the author has returned the sheet for press, the warehouseman delivers out the proper quantity of paper, which the pressman wets, by drawing the paper, to the extent of three, four, five, or six dips for each quire, through clean water, according as the paper may be hard sized or porous, and also as the form may be solid or open; the paper as it is wetted is laid upon a board, opened out, and another board is laid upon it with weights; on the following day it is turned, which causes fresh surfaces to come into contact with each other, and diffuses the moisture equally throughout every part of the heap; it will be in good condition to print on the next day. This wetting the paper causes it to receive the impression of the ink in a much more perfect manner than it could possibly be made to do if dry.

The pressman having received the forms, lays the inner form on the press, and prints one copy, which is called a revise; this he takes to the person appointed to revise it, and while that is doing, proceeds to secure the form on the table of the press by means of quoins; to place his tympan sheet; to fix the points which make small holes in the paper that enable him to cause the pages to fall precisely on the back of each other when the second side of the paper is printed, and to produce an even and uniform impression in all the pages: he then cuts his frisket, which preserves the margin of the paper clean, and, when the revise is corrected, proceeds to ink the surface of the types by means of balls or rollers. When the whole impression of one side of the paper is printed, he lifts the form off the press, washes the ink off the face of the type with ley, and rinses it with water. He then proceeds in a similar manner with the outer form, which completes the sheet; and thus sheet after sheet.

If it be intended to have large paper copies of a work, the alteration of margin is made when the number of small paper copies is printed off from each form.

When the sheet is printed, the compositor lays it up, distributes the letter, and proceeds, sheet after sheet, till the body of the work is finished; then the title, dedication, preface, introduction, contents, and any other prefatory matter is proceeded with, these being always printed the last.

The warehouseman then takes the printed sheets away, and hangs them up on poles to dry, varying the number of sheets hung up together from five or six to ten or eleven, according to the state of the weather, the heat of the room, or the pressure of business; when these sheets are dry they are taken down from the poles, carefully knocked up, and put away in the warehouse in piles; when the book is nearly finished, from ten to fourteen consecutive sheets are laid upon the gathering table in order, and collected sheet by sheet by boys, who deposit each gathering in a heap at the end of the table, which is generally what is styled a horse-shoe table, so that when a boy has deposited his gathering he has only to turn himself and begin again. These gatherings are then carefully collated, to ascertain that the different sheets are correct and in order, and folded up the middle. When the work is finished the gatherings are put together, each of which forms a copy of the work, and pressed; the work is now completed, and awaits the order of the bookseller, &c., to deliver the copies either to himself, the bookbinder, or to others, according to circumstances.

The foregoing is the general description of the manner in which printing is conducted. Each style of work has its own peculiarities, and each office has details appropriate to itself. Philadelphia, Boston, and New-York, are the cities where the great bulk of book printing of this country is performed. Some of the printing offices of these cities are conducted on a most extensive scale. In that in which this Cyclopedia is stereotyped and printed (Mr. J. F. Trow's), there are steadily employed, in the various departments of proof-reading, composing, and press-work, about 140 persons. In the composing department, where every description of book and job printing is executed—including works in the Oriental and Classical languages—the average amount of daily labor performed is equivalent to a duodecimo volume of 350 pages. In the press-rooms, there are 13 improved Adams' presses, one cylinder, and three hand-presses, throwing off daily about 68,750 impressions—equal to 4,590 duodecimo volumes of 350 pages. Some of the finest specimens of American typography have issued from this extensive establishment—particularly in the Oriental department, in which branch we believe Mr. Trow has no competitor in this country.

In this country, females are employed in some cities as compositors.

The number of people engaged in these employments is perhaps about the same in the United States, as in Great Britain and in France. Germany employs twice as many as either of those countries; the rest of Europe, collectively, as many as France. In all, at least 150,000 families subsist in the civilized world, by imparting knowledge or creating the facilities, besides the clergy and the instructors in schools, perhaps twice as many more. (*See* PRINTING-PRESS.)

PRINTING INK is made of oil-varnish and fine lampblack. The varnish is made by heating pure linseed oil in a copper till it will light with a piece of lighted paper. It is then made to burn away to three quarters, to two thirds and one half for varnishes, of various consistence. The lampblack is the soot of turpentine lamps, burnt in a close chamber, and the soot collected on flannels which line the room, and from to time are beat out. In a large way the oil is not burnt, but evaporated, at nearly a boiling heat, to a thick consistence; lampblack is often made by burning pitch, resin, &c., and collecting the soot in a horizontal chimney, which passes into a chamber hung with coarse cloths or flannels. The ink is made by gradually triturating the black with the varnish on a stone with a muller, but in the large way this is done by a horse-power with a wheel, in the manner of color-grinding. Balsam copaiba, soap, resin, and indigo are used by some as ingredients in the ink.

After the smoke begins to rise from the boiling oil, a bit of burning paper stuck in the cleft end of a long stick should be applied to the surface, to set it on fire, as soon as the vapor will burn; and the flame should be allowed to continue (the pot being meanwhile removed from over the fire, or the fire taken from under the pot), till a sample of the varnish, cooled upon a pallet-knife, draws out into strings of about half an inch long between the fingers. To six quarts of linseed oil thus treated, six pounds of resin should be gradually added, as soon as the froth of the ebullition has subsided. Whenever the resin is dissolved, one pound and three quarters of dry brown soap, of the best quality, cut into slices, is to be introduced cautiously, for its water of combination causes a violent intumescence. Both the resin and soap should be well stirred with the spatula. The pot is to be now set upon the fire, in order to complete the combination of all the constituents.

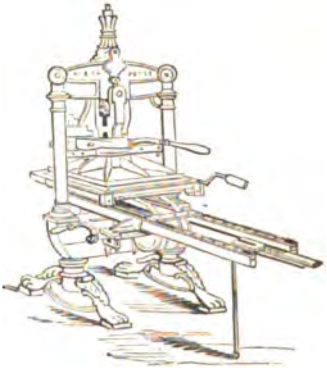
Put next of well ground indigo and

Prussian blue, each 2½ ounces, into an earthen pan, sufficiently large to hold all the ink, along with 4 pounds of the best mineral lampblack, and then 3½ pounds of good vegetable lampblack; then add the warm varnish by slow degrees, carefully stirring, to produce a perfect incorporation of all the ingredients. This mixture is next to be subjected to a mill, or slab and muller, till it be levigated into a smooth uniform paste.

One pound of a superfine printing ink may be made by the following recipe of Mr. Savage:—Balsam copaiba, 9 oz.; lampblack, 3 oz.; indigo and Prussian blue, together, p. æq. 1¼ oz.; Indian red, ¾ oz.; turpentine (yellow) soap, dry, 3 oz. This mixture is to be ground upon a slab, with a muller, to an impalpable smoothness. The pigments used for colored printing inks are, carmine, lakes, vermilion, red lead, Indian red, Venetian red, chrome yellow, chrome red or orange, burnt *terra di Sienna*, gall-stone, Roman ochre, yellow ochre, verdigris, blues and yellows mixed for greens, indigo, Prussian blue, Antwerp blue, lustre, umber, sepia, browns mixed with Venetian red, &c.

PRINTING-PRESS (TYPE) is the very important implement used for transferring the impressions of inked types to paper. The first printing was effected by a flat board with blows of a mallet. But the number of impressions rendered it necessary to convert the board into a solid platten, and carry this upon the paper, by means of a screw, and a lever to turn it. The types were inked with large balls, made of sheep's pelt, and the soft covering placed over the paper, to protect the types, and bring the paper into contact with the entire surface of each type; but, in time, this has been changed into the tympan-frame of parchment and interposed flannel. Such, with some changes and varieties in the parts, is the ordinary printing-press, which takes off from 250 to 300 impressions per hour.

Very little improvement in the construction of this instrument took place from the first introduction of the art into Europe till the late Earl Stanhope applied the powers of his mind to the subject, and introduced a new press of a decidedly superior construction. The old press was made of wood, with an iron screw that had a bar fitted in it; to the lower end of this screw was attached, horizontally, a flat piece of wood, called the platen, which was brought down by means of the screw, and pressed the paper upon the face of the types; and thus the impression was obtained This press has, however, entirely given place to presses made of iron. Lord Stanhope's press is constructed of iron with a screw; but the bar is fixed to an upright spindle, to which a lever is attached connected with a second lever fixed to the top of the screw by a connecting bar. These two levers are placed at different angles to each other; and when the platen is brought down to the face of the types, and power is wanted, the two levers take such a position with each other as to act with the greatest advantage, and thus an almost incredible accession of power is gained, which enables the pressman to print larger sheets of paper in a superior manner, with less labor, and with greater ease to himself. It does not act by a continuous, but by a reciprocating motion, and can only print 250 impressions per hour. This press for a long time maintained its superiority over all others.



This great improvement in the printing press that Lord Stanhope had accomplished, excited other ingenious men to exert their abilities in attempts at further improvements; among whom was a Mr. George Clymer, an American, who brought forward an iron press, called the Columbian press, in which he discarded the screw, and obtained his power entirely by levers. This press has great power, and consequently great strength, and is made of a size to print larger sheets of paper than any other; but for the common run of printing it does not work so easy as the Stanhope press.

The common printing-press in which the

impression is given by a compound lever acting on an inclined plain, is found sufficiently powerful to print a newspaper form of the size of 42×26 inches, having a chase 4 inches larger each way. It requires two persons to work it, one of whom inks the form with the rollers and does nothing else. The other performs the principal labor, putting on and taking off the sheet, rolling the form under and from under the platen, and giving the pull, which is necessarily a heavy one. The exertion required to throw off 250 impressions in an hour at a press of this size is very great, and that quantity cannot well be exceeded.

The platen power-press of the best construction has self-inking rollers and a fly for removing the printed sheet from the type, and laying it on the heap. It is worked by two persons, one of whom, a stout man, keeps it in motion by turning a crank attached to a fly-wheel, and the other performs the light duty of putting on the sheets. The bed and platen are immense masses of cast iron, intended by their strength to guard against an inclination to spring, which is very apparent in the hand-press, and partially corrected by making the bed and platen slightly concave on their face. The platen power-press when calculated to print a form of 42 by 26 inches, will weigh 8,090 pounds, and when worked by one man at the crank as usual, may give 400 impressions in an hour, or if greater speed be required, with the aid of a steam engine, it may be safely worked at 600 impressions per hour. It is a great improvement on the hand-press, whether used for book or newspaper printing.

Among the bed and platen presses, the most valuable and most extensively used, are those manufactured by Mr. J. Adams, of Boston. Mr. Adams took out a patent in 1830, for a power-press, and in 1836 another for an improved power-press. The number of improvements claimed in the specification of this latter patent exceeded twenty in number, some of which were as ingenious as they were novel. Mr. Adams's press was the first in this country to which a fly frame was attached. It requires but one person (a woman) to tend it and put the paper on the register pins; from which it is removed by the fingers or clips which carry it along under the platen, where it remains for a second to receive the impression of the type. The latter, placed upon a movable bed, travels on to receive the ink from the self-acting rollers, returns, and when immediately below the platen is carried upwards by the action of a crank underneath, and is pressed against the surface of the paper: it is then lowered, passes against a side table, inked, returns, and renews the operation. The impressed sheet is carried horizontally on tapes some distance, when it has to rise an inclined plane of tape to come within the reach of the fly frame. The attraction from the horizontal to the ascending direction is ingeniously effected by means of a bellows acted upon by the press itself, which blows the leaf up at the edge, and thus raises it over the first difficulty, that of altering its direction. It is removed from the tapes by the fly frame. The whole is effected with great rapidity and little noise. It throws off more work than any English press of a similar kind, the larger size printing readily 600 copies per hour. It is adapted for stereotype and letter-press, as well as wood-cut printing.

The cylinder press is the great invention of the day for fast printing; and it is made with a small or large cylinder, according as it is to be used for newspaper or book work, the former being most favorable to rapid printing, and the latter to good impressions. It has self-inking rollers, pointing apparatus, and a sheet-flyer. When it is to be worked at its greatest speed, it must be impelled by a steam-engine, and then 2,500 impressions of a form of 42 by 26 inches may be conveniently taken in an hour, and possibly 3,000, if the paper can be fed to it by one person so fast. When it is driven by a man with a crank and fly-wheel, 800 impressions of the same form may be taken in an hour, and the work of feeding the press with paper at this rate may be done, and usually is done, by a boy or female. All cylinder presses, however, are intended to be used for rapid work occasionally, if not usually, and are therefore made with heavy frames and strong working parts, to endure the rapid motion and the sudden reverses which attend the printing of 50 impressions in a minute or 3,000 in an hour.

From the preceding statement it thus appears that when two persons work either of the above presses, the hand-press gives 250 impressions, the platen power-press 400 impressions, and the cylinder press 800 impressions, per hour: the platen power-press, though much heavier than the hand-press, giving double its number of impressions by a better application of man-power; and the cylinder press giving four times its number of impressions by a still better application of the same power on a lighter machine; the difference in the movement of the respective presses being pretty fairly represented by saying, that the hand-press is in actual motion one-third of its time, the platen power-press two-thirds, and the cylinder press all its time, the first and second dwelling upon the impression of the whole form with great force, while the latter rolls over the form lightly, impressing only about an 80th part of it at once.

The **Printing Machine**, is the adaptation of the printing-press to the moving power of steam. The types are laid on a stage, imposed in the usual manner, first one side of the sheet, and then, a little beyond it, the other side. They are inked by passing under rollers which are supplied with ink from above. The paper is then placed on a large roller by a boy, and the roller turning passes and presses the paper over the type, producing a perfect impression on one side. The sheet is then reversed by small rollers and carried to the next roller, which turns it over the other form of type and perfects it, when a boy removes it. During this time the first boy had laid another sheet off the first roller, the types had returned under the rollers, and received fresh ink from the ink rollers, the first roller had turned, the two small rollers had laid the reversed sheet on the second roller, which had turned and perfected it, and in the 9th or 12th of a second of time the last boy receives another sheet. The number perfected being from 2,000 to 8,000 per hour, or 20 times the number by ordinary press-work, performed by two hands and a boy.

The printing-machine was invented by Mr. König, a Saxon, who considered that steam might be employed with advantage to expedite the process of printing; but not receiving encouragement on the Continent to enable him to prosecute his plans, he came to England in 1804, and, after explaining his views to some of the principal printers in London, Mr. Bensley, Mr. Woodfall, and Mr. Taylor, embarked in the undertaking, but Mr. Woodfall soon withdrew. After innumerable experiments, and a great outlay of capital, the result was not satisfactory; but the experience gained by prosecuting these experiments resulted in the production of a machine to print with cylinders instead of a flat surface, as was the case with the printing press, which was limited in the size of the paper by the size of the press and the power of the pressman. In cylindrical printing, by which the pressure is communicated in lines, the size may be very considerably increased.

The first machine that was constructed was capable of printing 1000 copies per hour of double demy paper on both sides, while a hand-press is estimated to print 250 copies of a single sheet on one side only, in the same time.

When this machine was completed, the proprietors of the *Times* newspaper, ever ready to adopt any improvement that would expedite its publication, without regarding expense, agreed with the patentees for two machines, and on the 28th of November, 1814, the *Times* was published, executed by cylindrical printing, the moving power being steam; these were the only machines constructed under the first patent—they threw off 1,800 per hour.

In 1815, Mr. Cowper, of England, obtained a patent for curving stereotype plates, for the purpose of fixing them on a cylinder. Several machines so mounted, capable of printing 1000 sheets per hour upon both sides, are at work at the present day; twelve machines on this principle having been made for Directors of the Bank of England a short time previous to their re-issuing gold.

Nicholson sought to effect the revolution of the form of types by giving to the shank of a type a shape like the stone of an arch; Donkin and Bacon by attaching types to the sides of a revolving prism; and Cowper, more successfully, by curving a stereotype plate. In these machines Mr. Cowper places two paper cylinders side by side, and against each of them a cylinder for holding the plates; each of these four cylinders is about two feet in diameter. Upon the surface of the stereotype plate cylinder, four or five inking rollers of about three inches in diameter are placed; they are kept in their position by a frame at each end of the said cylinder, and the axles of the rollers rest in vertical slots of the frame, whereby, having perfect freedom of motion, they act by their gravity alone, and require no adjustment.

The frame which supports the inking rollers, called the waving-frame, is attached by hinges to the general framework of the machine; the edge of the stereotype-plate cylinder is indented, and rubs against the waving-frame, causing it to vibrate to and fro, and consequently to carry the inking rollers with it, so as to give them an unceasing traverse movement. These rollers distribute the ink over three-fourths of the surface of the cylinder, the other quarter being occupied by the curved stereotype plates. The ink is contained in a trough, which stands parallel to the said cylinder, and is formed by a metal roller revolving against the edge of a plate of iron; in its revolution it gets covered with a thin film of ink, which is conveyed to the plate cylinder by a distributing roller vibrating between both. The ink is diffused upon the plate cylinder as before described; the plates in passing under the inking rollers become charged with the colored varnish; and as the cylinder continues to revolve, the plates come into contact with a sheet of paper on the first paper cylinder, which is then carried by means of tapes to the second paper cylinder, where it receives the impression upon its opposite side from the plates upon the second cylinder.

Thus the printing of the sheet is completed. Though the above machine be applicable only to stereotype plates, it has been of general importance, because it formed the foundation of the future success of Messrs. Cowper and Applegath's printing machinery, by showing them the best method of serving out, distributing, and applying the colored varnish to the types.

In order to adopt this method of inking to a flat type-form machine, it was merely requisite to do the same thing upon an extended flat surface or table, which had been performed upon an extended cylindrical surface. Accordingly, Messrs. Cowper and Applegath constructed a machine for printing both sides of the sheets from type, including the inking apparatus, and the mode of conveying the sheet from the one paper cylinder to the other, by means of drums and tapes. It is highly creditable to the scientific judgment of these patentees, that in new modelling the printing machine they dispensed with forty wheels, which existed in Mr. König's apparatus, when Mr. Bensley requested them to apply their improvements to it.

In England, Treadwell's power-press has been, until lately, very much employed. In this invention the types are inked by elastic rollers, and the distribution of the ink rendered equal by a revolving table, which keeps in contact with the rollers. The impressions are made by a flat surface, or platen, instead of a cylinder, so that cleaner and better impressions are supposed to be obtained from it, than by any other machine.

König's machine continued in use by the Times newspaper (England) till 1827, when it was superseded by Applegath & Cowper's four-cylinder machine, producing 5000 per hour. Some of them are still used in that office. They consist of a table moving to and fro under four iron cylinders, about nine inches diameter, covered with cloth, and round which the paper is carried. The form is fixed at one part of the table, and the ink and paper at another. Some of the rollers were laid diagonally, so that as the table moved, the rollers had a motion in the direction of their length; this movement aided the rotatory one in better inking; the ink lay in in a trough in an iron roller or *dorter*, exactly similar to that used in *Calico printing* (which see). Four layers-on fed the rollers, which by tapes carried the sheets to the takers-out at the other end. In May, 1848, the last improvement was made by the adoption of a new machine, which threw off the large quantity of 10,000 copies per hour. This machine was a vertical cylinder, 65 inches broad, on which the type was fixed, surrounded by eight other cylinders, each about 13 inches diameter, and covered with cloth, round which the paper was led by tapes, each paper cylinder having a feeding apparatus and two boys tending. The ink rollers were also vertical against the large cylinder, and on which they distributed the ink. This last was in a vertical cylinder. The type used is the ordinary kind, and the form is placed on a portion of the large cylinder. The surface of the type formed a portion of a polygon, and the regularity of the impression was obtained by pasting slips of paper on the cylinders. On the 7th May, 1850, the Times newspaper and Supplement contained 72 columns or 17,500 lines made up of more than a million pieces of type; of this copy, the last form went to press at 4 45 A. M., 7000 copies were published before 6 A. M., 17,000 before 7 30 A. M., and 34,000 before 8 45 A. M., or in about four hours. On March 9th, 1850, an exhibition of a new rotary press took place in Paris, which was worked by cylindrical motion, and by a stereotype obtained from several sheets made of a pulp of paper, which gives more depth than is usually obtained from plaster of Paris, and the printing is so perfect, that even maps are produced from their cylindrical stereotypes with the minutest accuracy. It is the invention of Worms, once a Parrisian printer. The stereotype cylinder was got up in 15 minutes and the printing on both sides was most perfect. It knocked off 15,000 copies by the hour; this may be augmented by steam power. The rapidity is owing to the printing on endless paper not wetted on rollers, each copy being cut up with great precision.

This French rotary press has been excelled by the *mammoth press*, the largest ever constructed. It was designed and built by Messrs. Hoe & Co., New-York: it is forty feet in length and five wide; it has a large central drum which revolves like a broad wheel. The *form* (or there may be a number of them) is placed on the periphery of the central drum, but only occupies a portion of it. The *chase* is curved and forms the section of a circle, with the surface of the type forming the outside of the same. The type are secured in the curved chase in a peculiar manner. The column-rules are straight and run parallel with the shaft of the large drum; the head and dash-rules are curved. The column-rules have bottom flanges; they slide in the grooves in the bed of the chase, and are secured by brass dove-tail wedges. The cross section of a column-rule is of a wedge shape, being thinner at the bottom than at the top, to wedge in the type at the widest part of a circle which they form with the large drum. This is an essential feature in securing the type, and its application is certainly the result of a very happy thought. The type is firmly screwed up in the chase by set screws.

The surface of the large drum of the press is composed of smooth metal plates, and performs the office of an ink distributor to the small rollers which ink the type. Below the large rotary drum, there is a trough running across the frame, into which the ink is pumped from a reservoir by a force pump, so as to keep the trough always full. Above the ink trough there revolves a large roller, which takes up the ink on its surface, conveys it to another roller, that one to a third, and it to the smooth surface of the revolving drum, distributing the ink on it. The use of the three rollers to convey the ink from the trough, is to work and spread it on the distributing surface. As the type in the *chase* stands higher than the smooth surface of the rotary drum, the ink-roller below would cover the type with ink when it came round to it, were it not for a contrivance of Messrs. Hoe to obviate this difficulty. The large ink-roller below has its gudgeons worked on springs, which press it up against the smooth surface of the large drum, except at the exact time during the passage of the type: then a cam forces down the ink-roller below the surface of the type, until the *form* is past the point of contact, when it rises up against the distribution surface with its supply of ink.

Around the fixed frame at different but exact points above the large *drum*, there are eight revolving tympan cylinders, or rollers, which feed in the sheets to the revolving drum, and against the surface of which the *form*, as it revolves, impresses the paper. The attendants push in the sheets, one by one, to the tympans, in each of which is an open section, with fingers worked by a cam, which are open when they come round to receive a sheet, then close upon it, wrapping the said sheet around the smooth surface of the tympan; at this very period, the type on the large drum has come round, and is acting on the paper. When the type has printed the sheet, the fingers spoken of open like the human hand and the printed sheet is whipped off the tympan and carried away back to the end of the press, there to be taken off and folded neatly down by a vibratory flyer, four of which are placed one above another, (one for each tympan,) at each side of the press. The two outside edges of each sheet of paper are held against a smooth narrow strap on the tympan on each side. Above each tympan cylinder it will be observed there are a number of small pulleys, with straps running around them, extending the whole length of each tympan, and running on its surface. The straps of these small pulleys run away back over a like set of pulleys, above the flyers. Whenever the type forms its impression on the sheet, the fingers spoken of let the paper free, and then these small straps whip up the sheet and carry it along, as on a flying railroad, to be folded by the flyer. After the form makes its impression on the paper which is wrapped around the tympan, it comes in contact with the two small ink-rollers, which ink the surface of the type, and fit it to print the sheet on the next tympan, and so on continually. These small inking rollers have their journals fitted on springs, so as to allow them to be pushed up or down by the type, and then to be forced against the distributing surface, to take up the ink for their next performance.

In this one press, it may be said,

"their are eight combined," that is, in respect to its effective power. One, two, three, or more tympan cylinders can be detached, and the rest left free to work. This makes it very convenient, for it requires but a moment's labor to set the press so as to work with any number less than the eight attendants.

Although this machine is so large, strictly speaking it is exceedingly simple in its operaiton, and it works with a smoothness and regularity that commands admiration. The building of this great press for the New-York Sun was commenced in 1849, and it was completed in 1851.

In the construction of this press Messrs. Hoe & Co. state that there are employed no less than six thousand bolts and screws, one thousand two hundred wheels, two hundred and two wooden rollers, four hundred pulleys, four hundred tape guides, besides an amazing amount of cogged wheel connections, arms, braces, and other connections. There are also required to give motion to various parts of the machine, no less than five hundred yards of belting.

It can print 20,000 copies in one hour. It has been in successful operation printing the New-York Sun for the past six months, and it operates with astonishing precision.

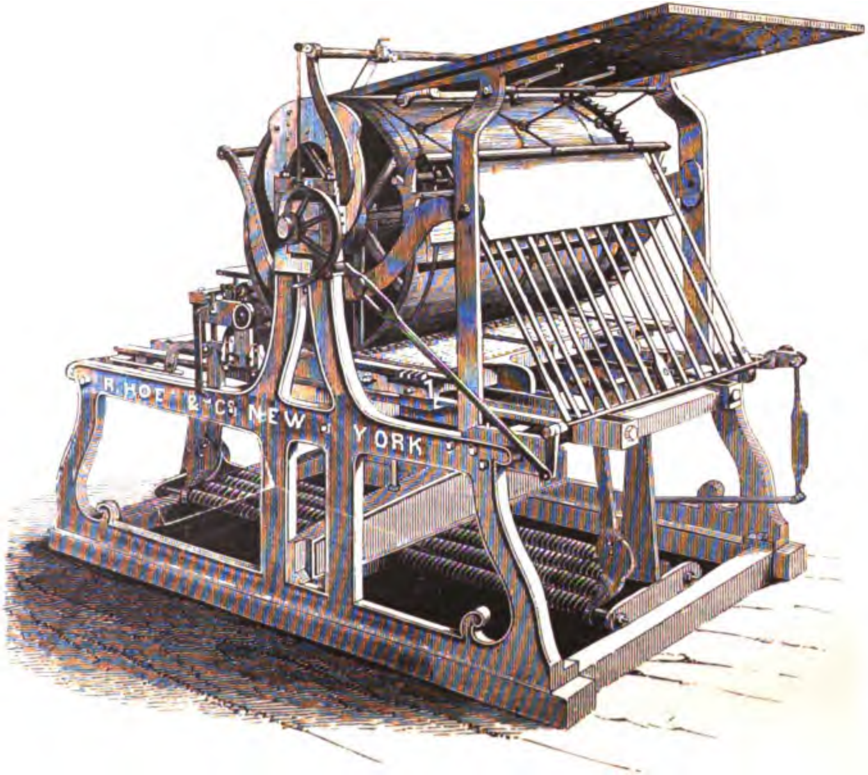
The manufactory of Messrs. Hoe & Co., N. Y., is the most extensive one of its kind in this country. In it are made several varieties of presses, both cylinder and platen; a description of those manufactured in that establishment to a great extent comprehends the notice of those presses most in use. Among the cylinder presses are,

1. The *Type Revolving Fast Printing Machine*, the mechanism of which is as follows:—

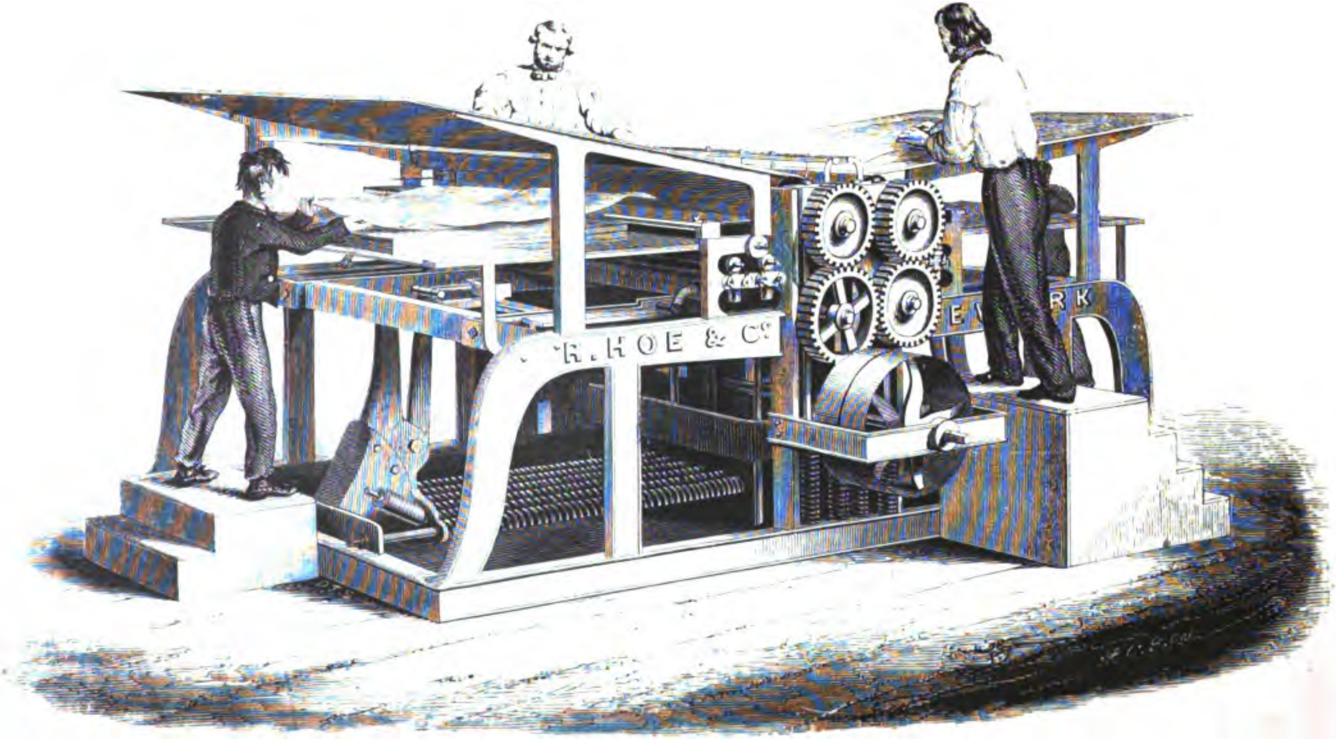
A horizontal cylinder of about four and a half feet in diameter, is mounted on a shaft, with appropriate bearings; about one-fourth of the circumference of this cylinder constitutes the bed of the press, which is adapted to receive the form of types—the remainder is used as a cylindrical distributing table. The diameter of the cylinder is less than that of the form of types, in order that the distributing portion of it may pass the impression cylinders without touching. The ink is contained in a fountain placed beneath the large cylinder, from which it is taken by a ducter roller and transferred, by a vibrating distributing roller, to the cylindrical distributing table; the fountain roller receives a slow and continuous rotary motion, to carry up the ink from the fountain.

The large cylinder being put in motion, the form of types thereon is, in succession, carried to four or more corresponding horizontal impression cylinders, arranged at proper distances around it, to give the impression to four or more sheets, one introduced by each impression cylinder. The fly and feed-boards of two of the impression cylinders are similar to those on the well-known double cylinder press; on the other two, the sheet is fed in below and thrown out above. The sheets are taken directly from the feed-board, by iron fingers attached to each impression cylinder. Between each two of the impression cylinders there are two inking rollers, which vibrate on the distributing surface while taking a supply of ink, and at the proper time are caused to rise, by a cam, so as to pass over the form, when they again fall to the distributing surface. Each page is locked up upon a detached segment of the large cylinder, called by the compositors a "turtle," and this constitutes the bed and chase. The column-rules run parallel with the shafts of the cylinder, and are consequently straight; while the head, advertising, and dash-rules are in the form of segments of a circle. A cross section of the column-rules would present the form of a wedge, with the small end pointing to the centre of the cylinder, so as to bind the types near the top; for the types being parallel, instead of radiating from the centre, it is obvious that if the column-rules were also parallel, they must stand apart at the top, no matter how tight they were pressed together at the base; but with these wedge shaped column rules, which are held down to the bed or "turtle" by tongues, projecting at intervals along their length, and sliding in rebated grooves cut crosswise in the face of the bed, the space in the grooves, between the column-rules, being filled with sliding blocks of metal, accurately fitted, the outer surface level with the surface of the bed, the ends next the column-rules being cut away underneath to receive a projection on the sides of the tongues, and screws at the end and side of each page to lock them together, the types are as secure on this cylinder as they can be on the old flat bed.

A press with four impression cylinders is capable of printing 10,000 im


R. HOE & CO. NEW YORK

PATENT SINGLE LARGE CYLINDER PRINTING MACHINE. Page 400



HOE & CO.'S PATENT IMPROVED CYLINDER PRINTING MACHINE. Page 499.

pressions per hour. Four persons are required to feed in the sheets, which are thrown out and laid in heaps by self-acting flyers, as in our ordinary cylinder presses. A press with eight impression cylinders will print 16,000 or more impressions per hour.

2. *The Single Small Cylinder Printing Machine.* In this press the form is placed on a flat bed, and the impression taken on the paper by a cylinder while the form is passing under it. The diameter of the cylinder is small, allowing of compactness, and increases the number of impressions in a given time. One person only is required to feed it, and it gives from 2,000 to 3,000 impressions per hour. The printed sheets are thrown out by a fly frame. By the addition of a register point apparatus it is rendered fit for book printing. It may be driven by hand or steam.

3. The *Double Cylinder Printing Machine*, has an arrangement similar to the foregoing, with the addition of another impression cylinder, which gives an additional impression from the same form. Two attendants supply the sheets, which is all that is required for large editions, but where small editions are worked off two boys extra are required to take out. A view of this press is given in the accompanying page.

4. *Patent Single Large Cylinder Machine.* In this the cylinder is of greater diameter than in any of the foregoing. It has a perfect register and sheet flyer, and adjustable bearers of iron, so that stereotype may be worked on it. One boy is required to feed, and it gives from one to two thousand impressions per hour. Man or steam power may be used. India-rubber impression cloths are used with these presses. An illustration of this press is here subjoined.

5. The *Little Jobber.* This press combines speed with durability. It is capable of throwing off 2,500 impressions per hour. It may be driven by the foot and treadle. The manner of running the bed is original, being accomplished by a crank and lever, which gives it a slow and uniform motion, while the impression is being taken, and a quick retrograde motion. The sheet-flyer is so arranged that no tapes pass round the impression cylinder, no matter what the size of the form may be that is worked, and thus no tapes or fingers have to be shifted. It has iron feed and fly boards, and adjustable fountain, knife, and bearers.

The *Patent Washington Hand Press*, and the *Patent Smith Press*, are convenient forms of the bed and platen variety.

Messrs. Hoe have attached to these presses self-inking rollers, which may be thus described. The large distributing cylinder vibrates: there are two rollers to ink the forms, moving in a carriage with four wheels. The wheels on one end are plain, those on the other have a projecting flange in the middle of the rim. Two wrought iron rails are on the bed outside of the chase, one of them having a groove cut in its top to receive the projecting flanges on one pair of the wheels, the other level on the surface. Projecting from the distributor frame are two short rails, on which the wheels rest while the rollers receive ink from the distributing cylinder. The machine is set up behind the press so that the short rails on it shall agree exactly with the rails on the bed of the press, when it is run out, both in height and width. The brasses in which the inking rollers run, have regulated adjusting screws, so that they may bear more or less on the type as circumstances may require.

PROMETHEANS. A term applied to small glass tubes containing concentrated sulphuric acid, and surrounded with an inflammable mixture, which they ignite on being pressed, and thereby give instantaneous light.

PROOF. In engraving, an impression taken from an engraving to prove the state of it during the progress of executing it; also one taken before the insertion of the letters are engraved on the plate.

PROOF. In printing, an impression on which the errors and mistakes are marked for the purpose of being corrected. Proofs are first proof, which is the impression taken with all the errors of workmanship. After it is read by the copy, and the errors corrected, which if not many, and carefully done, another impression is printed with more care, to send to the author; this is termed a clean proof. On it he makes his corrections and alterations: when those are altered in the types, another proof is printed, and read over carefully, previously to the whole number being printed off; this is called the press proof.

PROOF SPIRIT. A mixture of equal weights of absolute alcohol and water; the specific gravity of such a mixture is 0·917; but the density of the proof spirit of commerce is 0·930.

PROPAGATION OF PLANTS.

Plants are propagated by seed, by runners, suckers, offsets, dividing the tubers, layers, cuttings, grafting, budding, inarching, &c. Seeds are gathered when mature, and sown on recently stirred soil, and covered to different depths, according to the size of the seed, the nature of the soil and situation, and other circumstances. The plants formed by runners are separated from the parent plant by cutting through the runner, and removing the young plant, in order to plant it elsewhere. Suckers, slips, or side-shoots from the roots, are separated from the parent plant by being slipped down, or cut off, so as to carry with them a portion of fibrous roots; and they are afterwards planted in suitable soil, &c. Offsets are small bulbs which are produced round the base of larger ones, and, being taken off and planted, become plants. Tubers are underground stems, containing leaf-buds; and these may be separated and planted entire, or cut into as many pieces as there are buds, in either of which cases new plants will be formed. Layers are branches or shoots of either woody or herbaceous plants, which are bent down, and a portion of their length buried a few inches in the soil; that portion having been previously wounded by cutting, bruising, or twisting, which, by checking the descent of the sap, gives rise, after a certain period, to the production of roots. After these roots are formed, the portion of the layer which has produced them is separated from the main stock or parent plant, and planted by itself. Cuttings are portions of shoots, either of ligneous or herbaceous plants; and they are made of the young shoots with the leaves on, or of the ripened wood either with or without its leaves; and after they have, either in a herbaceous state with the leaves on, or with the wood mature and with or without the leaves, been properly prepared and planted, they form roots at their lower extremity, each cutting becoming a perfect plant. In general, cuttings should be taken from those shoots of a plant which are nearest the soil; because, from the moisture and shade there, such shoots are more predisposed to emit roots than those on the upper part of the plant. The young or last-formed shoots are to be taken in preference to such as are older, as containing more perfect buds in an undeveloped state, and a bark more easily permeable by roots; and the cutting is to be prepared by cutting its lower extremity across at a joint, the lenticells or root-buds being there most abundant.

PRUNING. The art of cutting off parts of plants, and more especially of trees and shrubs, with a view to strengthening those which remain, or of bringing the tree or plant into particular forms, calculated to increase particular products. Pruning, therefore, varies according to the kind of plant or tree to be pruned, and according to the object in view. In the case of forest trees, the general object of pruning is to increase the quantity of timber in the trunk by diminishing the side branches, commencing at the lower part of the tree when it is quite young, and gradually advancing upwards as the tree increases in growth. In the case of hedges, the object is to produce a dense mass from the ground upwards, which is effected by shortening the side branches. In the case of pruning trees which are cultivated for the sake of their fruit or blossoms, the object is to thin out the branches so as to admit the light and air more freely to their leaves and blossoms, and to concentrate and increase the nourishment to the branches which remain. In the case of trees, or shrubs cultivated for the beauty of their shapes, whether natural or artificial, the object of pruning is to deprive the trees or shrubs of all those branches which deviate from or interfere with the natural shape, or with the form which is intended to be produced by art. In pruning with a view to produce fruit, it is necessary to know on what description of branches and buds the fruit is produced. In some trees, as in the peach, it is generally produced on the wood of the preceding year; in others, as in the apple and pear, it is generally produced on wood of two years' growth; and in the vine it is produced on shoots of the current year. The general effect of pruning on plants is to increase their longevity; since the tendency of all vegetables is to exhaust themselves, and, consequently, to shorten their duration, by the production of seeds. In the operation of pruning, the shoots are cut off close to the buds, or at a distance from them not greater than the diameter of the branch to be cut off; because, without the near proximity of a bud, the wounds will not heal over. In shoots which produce their buds alternately, the cut is made at the back of the bud, sloping from it, so as that it may be readily covered by bark in the same or in the following year. This is readily done with a pruning knife, by a slanting cut, made at an angle of 45° with the direction of the branch; but, in the case of branches where the buds are produced opposite each other, either one bud must be sacrificed, or the branch must be cut off at right angles to its line of direction; and is more conveniently done by the pruning shears. The operation of pruning may in many cases be superseded by rubbing off, or, pinching out, the leaf-buds, so as to prevent superfluous shoots from being produced.

PRUSSIATE OF POTASH, or Ferrocyanide of Potassium. The ferrocyanuret of potassium is prepared by gently igniting carbonate of potassa with animal matters, such as horns, hoofs, or dried blood, in iron vessels, by which cyanuret of potassium and some cyanuret of iron are formed; the soluble parts are then washed out with water, and sulphate of iron added until the Prussian blue which is formed ceases to be decomposed by the free potassa contained in the solution; the ferrocyanuret of potassium is then set to crystallize, and separated by repeated crystallization from sulphate of potassa. It is thus obtained in truncated octohedral crystals of a yellow color, commonly called *Prussiate of potash*. It is much used in chemistry as a test for the metals.

PRUSSIAN BLUE. This salt is made by adding solution of a salt of iron to a solution of prussiate of potash. Green sulphate of iron is always employed by the manufacturer, on account of its cheapness, for mixing with solution of the ferroprussiate, in forming Prussian blue, though the red sulphate, nitrate, or muriate of iron would afford a much richer blue pigment. Whatever salt of iron be preferred, should be carefully freed from any cupreous impregnation, as this would give the pure blue a dirty brownish cast. The green sulphate of iron is the most advantageous precipitant, on account of its affording protoxide, to convert into ferrocyanide any cyanide of potassium that may happen to be present in the uncrystallized lixivium. The carbonate of potash in that iixivium might be saturated with sulphuric acid before adding the solution of sulphate of iron; but it is more commonly done by adding a certain portion of alum; in which case, alumina falls along with the Prussian blue; and though it renders it somewhat paler, yet it proportionally increases its weight; whilst the acid of the alum saturates the carbonate of potash, and prevents its throwing down iron-oxide, to degrade by its brown-red tint the tone of the blue. For every pound of pearlash used in the calcination, from two to three pounds of alum are employed in the precipitation. When a rich blue is wished for, the free alkali in the Prussian ley may be partly saturated with sulphuric acid, before adding the mingled solutions of copperas and alum. One part of the sulphate of iron is generally allowed for 15 or 20 parts of dried blood, and 2 or 3 of horn-shavings or hoofs. But the proportion will depend very much upon the manipulations, which, if skilfully conducted, will produce more of the cyanides of iron, and require more copperas to neutralize them. The mixed solutions of alum and copperas should be progressively added to the ley as long as they produce any precipitate. This is not at first a fine blue, but a greenish gray, in consequence of the admixture of some white cyanide of iron; it becomes gradually blue by the absorption of oxygen from the air, which is favored by agitation of the liquor. Whenever the color seems to be as beautiful as it is likely to become, the liquor is to be run off by a spigot or cock from the bottom of the precipitation vats, into flat cisterns, to settle. The clear supernatant fluid, which is chiefly a solution of potash, is then drawn off by a syphon; more water is run on with agitation to wash it, which after settling is again drawn off; and whenever the washings become tasteless, the sediment is thrown upon filter sieves, and exposed to dry, first in the air of a stove, but finally upon slabs of chalk or Paris plaster. But for several purposes, Prussian blue may be best employed in the fresh pasty state, as it then spreads more evenly over paper and other surfaces.

A good article is known by the following tests: it feels light in the hand, adheres to the tongue, has a dark lively blue color, and gives a smooth deep trace; it should not effervesce with acids, as when adulterated with chalk; nor become pasty with boiling water, as when adulterated with starch. The Paris blue, prepared without alum, with a peroxide salt of iron, displays, when rubbed, a copper-red lustre, like indigo. Prussian blue, degraded in its color by an admixture of free oxide of iron, may be improved by digestion in dilute sulphuric or muriatic acid, washing, and drying. Its relative richness in the real ferroprussiate of iron may be estimated by the quantity of potash or soda which a given quantity of it requires to destroy its blue color.

Sulphureted hydrogen passed through Prussian blue diffused in water, whitens it; while prussic acid is eliminated, sulphur is thrown down, and the sesquicyanide of iron is converted into the single cyanide. Iron and tin operate in the same way. When Prussian blue is made with two atoms of ferrocyanide of potassium, instead of one, it becomes soluble in water. The following process deserves peculiar notice, as the first in which this interesting compound has been made to any extent, independently of animal matter. Mr. Lewis Thompson, of Lambeth, received a well-merited medal from the Society of Arts for this invention. He observed that in the common way of manufacturing prussiate of potash, the quantity of nitrogen furnished by a given weight of animal matter is not large, and seldom exceeds 8 per cent.; and of this small quantity, at least one half appears to be dissipated during the ignition. It occurred to him that the atmosphere might be economically made to supply the requisite nitrogen, if caused to act in favorable circumstances upon a mixture of carbon and potash. He has found the following prescription to answer: Take of pearlash and coke, each two parts; iron turnings, one part; grind them together into a coarse powder; place this in an open crucible, and expose the whole for half an hour to a full red heat in an open fire, with occasional stirring of the mixture. During this process, little jets of purple flame will be observed to rise from the surface of the materials. When these cease, the crucible must be removed and allowed to cool. The mass is to be lixiviated; the lixivium, which is a solution of ferrocyanide of potassium, with excess of potash, is to be treated in the usual way, and the black matter set aside for fresh operation with a fresh dose of pearlash. Mr. Thompson states that one pound of pearlash, containing 45 per cent. of alkali, yielded 1,355 grains of pure Prussian blue, or ferrocyanide of iron; or about 3 ounces avoirdupoise.

PRUSSIC ACID. Hydrocyanic or prussic acid, which consists of 1 atom of cyanogen=26,+1 at. of hydrogen = 1, is prepared by distilling the mercurial bicyanide in a glass retort with the saturating quantity of dilute muriatic acid. Prussic acid may also be obtained by precipitating the mercury by sulphureted hydrogen gas from the solution of its cyanide; as also by distilling the ferrocyanide of potassium along with dilute sulphuric acid. Prussic acid is a very volatile light fluid, eminently poisonous, and is spontaneously decomposed by keeping, especially when somewhat concentrated.

Prussic acid is also obtained by exposing the horns, hoofs, and dried blood of animals, with fixed alkali to a red heat. United with iron it is Prussian blue, and for experiments may be abstracted from that pigment. A dog's palate being touched with a glass rod dipped in it, the animal falls dead instantly, and such are its usual effects on animal life.

Prussic acid exists in the skin of the kernel of the seeds which produce it, as bitter almonds, the cherry-laurel, &c., &c. It is a compound of carbon and nitrogen, called cyanogen, with hydrogen, and hence called hydro-cyanic acid. It operates in medicine in very small doses, on the principle of allaying irritability without disturbing respiration.

The tests commonly employed for the detection of prussic acid, are, the smell, the taste, and the reaction of the suspected substance on the addition of certain saline solutions—viz. the solution of nitrate of silver, sulphate of copper, and of any salt of iron containing the black oxide of that metal. Of these tests the most delicate, but perhaps least certain, is the sense of smell: while the ferruginous solution, one of the least delicate, is, perhaps, the most certain of all.

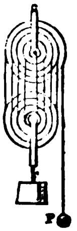
PUDDLING. This process has been explained under Iron manufacture. Instead of heat, electricity is now brought into play to effect the object, namely, the decarbonization and purification of the metal. A great economy in the conversion of the cast into wrought metal seems about to be effected in our iron works, by the application of a current of voltaic electricity to the crude iron in a state of fusion, whether on the hearth of the blast furnace, on the fused pigs in the sand, or on the metal immediately on its being run from the finery furnace; the voltaic force of from 50 to 100 pairs of a powerful Smee's battery being previously arranged to act upon the whole train of the metal. This process, for which Mr. Arthur Wall has recently obtained a patent, is founded upon the well-established fact, that when a compound is subjected to an electrical current, its negative and positive elements are detached from one another. Crude iron contains more or less carbon, sulphur, phosphorus, arsenic, oxygen, and silicon—bodies all electro-negative in relation to iron, which is electro-positive. When the impure iron, as it flows from the blast furnaces, is subjected during its cooling and consolidation to a powerful stream of voltaic electricity, the chemical affinities by which its various heterogeneous components are firmly associated, are immediately subverted, whereby, in the case of crude iron, the sulphur, phosphorus, &c., which destroy or impair its tenacity and malleability, become readily separable in the act of puddling.

The pecuniary advantage of this process, in respect of saving of labor and waste of material, has been estimated by competent judges at from five to ten dollars per ton.

The effect of electrising iron is displayed in a singular manner by the conversion into steel of a soft rod, exposed in contact with coke, for a few hours, to a moderate red heat.

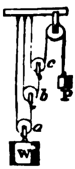
PULLEY. In mechanics, one of the six simple machines, or mechanical powers. It consists of a wheel, movable about an axis, and having a groove cut in its circumference, over which a cord passes. The axle is supported by a box or sheave, called the *block*, which may either be movable, or fixed to a firm support.

Fig. 1.



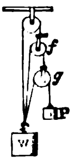
A single pulley serves merely to change the direction of motion; but several of them may be combined in various ways, by which a mechanical advantage or *purchase* is gained, greater or less, according to their number and the mode of combination. The purchase gained by any combination is readily computed by comparing the celerity of the weight raised with that of the moving power, according to the principle of virtual velocities, which is alike applicable to all machines of whatever kind. In fig. 1, which represents a system where the several portions of the cord are parallel to each other, suppose the weight W to rise one inch, the two blocks would approach each other by that quantity, and consequently, the length of cord connecting a single pair of pulleys would be shortened by 2 inches, so that the power P would descend 2 inches. Let the number of pulleys in each block be *n*; then, while the weight ascends 1 inch, the power descends 2 *n* inches, and, y, when there is equilibrium, the power is to the weight as 1 to 2 *n*.

Fig. 2.



In the combination represented in fig. 2, the purchase is much greater. Here the pulleys are all movable, and each is supported by a separate cord, having one end fastened to a fixed obstacle and the other attached to the succeeding pulley, excepting the upper block, which is fixed. It is evident that, for every inch the weight on the first pulley *a* ascends, the second, *b*, ascends two; the third, *c*, ascends four, and so on; the velocity being doubled by each additional pulley. The purchase finally obtained is, therefore, $=2^n$; or the power is to the weight as $1 : 2^n$.

Fig. 8.



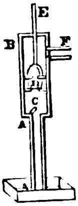
The third combination, fig. 8, has still greater efficacy. In this system, each cord is fastened to the weight, and, passing over a pulley, is attached to another pulley, excepting the last, which supports the power. While the weight W rises 1 inch, the first movable pulley, *f*, will sink 1 inch, which allows the cord applied to it to slacken 2 inches, and this joined to the inch which the weight ascends allows the second movable pulley, *g*, to descend 8 inches. This allows the next pulley in succession to descend 6 inches, which, joined to the 1 inch which the weight ascends, gives 7 inches for the descent of the third pulley. In like manner, it is found that the descent of the fourth pulley is 15 inches. Hence, one movable pulley allows the weight to descend $2 \times 1 + 1 = 3$ inches; two such pulleys, $2 \times 3 + 1 = 7$ inches; 3 pulleys, $2 \times 7 + 1 = 15$ inches; four pulleys, $2 \times 15 + 1 = 31$ inches, and so on; so that the purchase obtained by *n* movable pulleys, is $2^{n+1} - 1$, or the power is to the weight as 1 to $2^{n+1} - 1$. The theoretical advantage thus computed is, however, in all the cases, greatly diminished by friction, and the rigidity of the rope.

The two last combinations are of little, if any, use in practice, but various modifications of the first are common. *Smeaton's pulley*, or *Smeaton's tack*, as it is usually called, contains two rows of wheels, one under the other, in each block, and a single cord is made to pass over them in such a manner that the power and the weight both act in the same line with the centres of the two blocks, so that there is no tendency to twist. But this ingenious arrangement is open to several objections, and particularly the great amount of lateral friction of so many independent wheels. In White's pulley (see fig. 1.) the wheels in each block turn on the same axis, and, consequently, revolve in the same time; and they are of different sizes, their dimensions being so proportioned that a point on the circumference of any wheel moves with the velocity of the rope on that wheel. To effect this the diameter of the wheels in the upper block must be as the numbers, 1, 3, 5, &c., and in the lower as 2, 4, 6, &c. Instead of separate wheels, the upper and lower blocks are cut in grooves in the above proportions, whereby the friction is reduced to that of one wheel in each block.

PUMICE. A substance frequently ejected from volcanoes, of various colors, gray, white, reddish brown, or black; hard, rough and porous; specifically lighter than water, and resembling the slug produced in an iron furnace. It consists of parallel fibres, and is supposed to be asbestos decomposed by the action of fire. Pumice is of three kinds, glassy, common, and porphyritic. It is used for polishing ivory, wood, marble, metals, glass, &c.; as also skins and parchment. It is useful in cleaning cloth, and affording surface for decomposition in retorts; it consists chiefly of alumina.

PUMP. A machine for raising water. Though the forms under which this useful engine is constructed, and the mode in which the power is applied, may be modified in an infinite number of ways, there are only three which can be considered as differing from each other in principle. These are, the *sucking pump*, the *forcing pump*, and the *lifting pump*, so called from the manner in which they act.

Fig. 1.



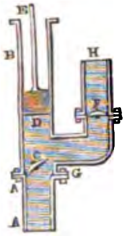
The *sucking pump*, or common household pump, is an apparatus of which the principle and construction will be evident from the annexed figure. A A is a pipe of any convenient length, the lower end of which reaches below the surface of the water in the well or reservoir; B is a barrel, generally of greater diameter than the pipe; C a valve opening upwards; D a piston moved by the rod E: in this piston there is also a valve opening upwards. When the piston is raised, the air in the barrel between the valves is expanded, and its tension, consequently, diminished; the pressure of the air in the pipe, therefore, opens the valve C, and the whole air in the pipe and barrel becomes less dense. In this state the atmospheric pressure on the surface of the water causes it to rise in the pipe, until the tension of the confined air becomes equal to the pressure of the atmosphere. On again depressing the piston, the valve in it opens, and the air passes through it from the barrel as it descends; but the valve C is closed by the downward pressure, and the volume of water which has entered the pipe remains. On again raising the piston, the same effect is repeated, and an additional quantity of water enters the pipe. Thus, by the alternating motion of the piston, a column of water is raised in the pipe until it reaches the piston when at the bottom of the barrel, and the whole of the air below it has been excluded. On raising the piston when the water has reached it, the fluid will be compelled to follow by the pressure of the atmosphere on its surface in the well. When the piston is again depressed, the water flows through the valve in it, and ascends into the barrel, and by the succeeding strokes of the piston is lifted up until it reaches and flows out of the spout F.

Although in theory the limit of the height to which water may be raised by the sucking pump, from the surface of the fluid in the well to the highest position of the movable piston, is about 34 feet, (the height of a column of water which balances the pressure of the atmosphere), it is not found practicable, with pumps of the ordinary construction, to raise it more than about 28 feet. The difference arises from the difficulty of making the apparatus absolutely air-tight.

The *chain pump* used in ships of war consists of an endless chain moving over a wheel on the gun-deck, which is turned by winches, and over a roller in the pump-well, having saucers or flat circular pistons at certain intervals. Near the pump-well, on the side on which the chain on turning the winches ascends, are a few feet of pipe; through this the saucers raise the column of water, which, being lifted over the upper orifice of the pipe, falls into the cistern, and thence into the waste-pipe, called the *pump-dale*, which carries it overboard. The descending portion of chain falls through another case called the *back case*. Chain pumps, in large ships, throw out a ton a minute.

The *forcing pump* is represented at fig. 2. The piston rod E D is attached to a solid plunger D, adjusted to the cavity of the barrel. A pipe G. H, furnished with a valve F, opening outwards, communicates with the barrel at G. On elevating the plunger D, the water will ascend through the valve C, in the same manner as in the sucking pump, till the barrel is filled to D. Now, when the plunger is depressed, the valve C will shut, and the water between D and C be forced through the valve F into the pipe G H. When the plunger is raised, the valve at F shuts, the pressure on its under side being removed, so that the water which was forced into the pipe by the previous stroke cannot return into the barrel. At the next stroke of the piston, more water is again forced into the pipe, and so on till it is raised to the height required.

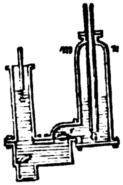
Fig. 2.



In this pump the pipe A A may be dispensed with, and the barrel B immersed in the reservoir; in which case the action of the pump is independent of the atmospheric pressure, and could be maintained equally well in a vacuum.

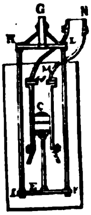
In order to produce a continued stream through the pipe G H, an air vessel, *m n*, may be attached to the lateral branch above the valve F, fig. 3. The pipe G H reaches too near the bottom of the air vessel; and when the water has been forced into the vessel by the action of the pump, until it reaches above the lower end of the pipe at G, it is evident that, as all communication is then cut off with the external atmosphere, every additional quantity of water thrown into the vessel will tend more and more to compress the air within it, which, acting by its pressure on the surface of the water, forces it through the pipe G H in a continued stream.

Fig. 3.



The *lifting pump* is represented by fig. 4. The barrel of the pump is immersed in the water and fixed to an immovable frame. The piston with its bucket and valve C, opening upwards, is attached at E to another frame, G H I K L, consisting of two strong iron rods, H I and L K, which move through holes in the framework to which the pump is fixed. An inclined branch M N, either fixed to the top of the barrel, or movable by means of a ball and socket, is fitted exactly to the barrel, and furnished with a valve at M. Suppose the barrel immersed in the water to a certain depth: if the piston frame be now thrust down by the handle at G, the piston will descend, and the water be forced by its upward pressure through the valve C, so as to maintain the level in the pump as in the well. But when the piston frame is elevated, the valve C will shut (as shown in the figure), and the water above C be *lifted up* with the piston, and forced through the valve M into the branch M N, from which its return will be prevented by the shutting of the valve M when the piston descends.

Fig. 4.



In each of these different kinds of pumps which have been described, the total effort required to work the machine, independently of friction, is equal to the weight of a column of water, the base of which is equal to the area of a section of the working barrel, and the altitude equal to the distance between the surface of the water in the reservoir and the point to which it is raised. In the sucking pump the whole of this effort is expended in raising the piston; in the forcing pump one part is expended in raising and the other in depressing the piston, and it is advantageous to dispose the machinery so that these two parts shall be nearly equal. In small pumps for domestic purposes, the strength of man is usually employed as the moving power; but in raising water from great depths, as the bottom of mines, the steam-engine is applied to this purpose. (*See* FIRE ENGINE.)

Mr. Von Schmidt, of New-York, has patented a centrifugal pump, which works thus: There are two circular flanges which are bolted together and form a hollow ring, with the sides, like two discs bolted together, forming a hollow chamber within, and having a wide circular circumferential chamber (hollow ring). There is an orifice of discharge, to which a pipe may be attached, and a pipe for a lower orifice on the other side communicates, air-tight, with the water in the well, or other place. The shaft runs through the pump, and has a stuffing box to render it air-tight when it passes into and out of the circular chamber, a large pulley aided by a band from any power revolves the arms inside to raise and force the water. The blades of the arms run in the circumference or hollow ring, and the arms revolve between the two sides. The blades are not stuffed nor fitted to run stiffly in the hollow ring, a thing common to other rotary pumps, and which causes much friction, a rapid wear of rubbing surface, and hence consigns them to an early tomb. It is, on the other hand, fitted to run with ease, like a blower; so that its passages do not get clogged up, and sand, gravel, &c., do not injure it. It requires no inside packing; all the parts are simple, easily cast and put together. Pumps of this kind are made capable of discharging from 5 gallons to 5,000 gallons of water per minute with suction pipe of wrought or cast iron, copper or lead, or flexible pipe of leather or India rubber; also discharge pipe of iron, copper or lead, and hose of leather, India rubber, or gutta percha. It is both a suction and force pump; and may be used as a fire engine by simply attaching hose to the discharge-pipe: by increasing the power, the quantity of water discharged will increase proportionately. Its movement being rotary, this increase may be indefinite; or up to the point of velocity with which water will fill a vacuum. It has been adopted by the United States government in the construction of the Water Battery on Staten Island, harbor of New-York, and at the extensive fortifications now in progress on the Tortugas Keys, Florida, and it is useful for almost every hydraulic purpose.

PURIFICATION of GOLD and SILVER, by antimony. (Under the article ASSAY and METALLURGY, this has been partly treated of.) The gold is to be melted in a crucible large enough to contain thrice the quantity of metal. When the gold is melted, twice its weight of sulphuret of antimony powdered is to be thrown upon it, the crucible is to be covered, and left some minutes in fusion; after which, when the mixture is well fused, and so hot that its surface sparkles, it is quickly to be poured into an iron cone, previously heated and greased. This matter consists, when cold, of two substances: the upper one of the sulphur of the antimony, united with the metals with which the gold was alloyed, and the lower is the gold united with a quantity of the antimony proportionable to the quantity of metals which have been separated from the gold, and which are now united with the sulphur of the antimony.

As a single fusion is not generally sufficient to disengage the gold from all its alloy, it ought to be fused again in the same manner, and with the same quantity of sulphuret of antimony. When these first fusions have been well made, the gold obtained is alloyed with antimony only.

It is then to be put into a large crucible, and heated sufficiently to keep it in good fusion. With this heat the antimony will be dissipated into smoke, and the operation must be performed slowly, but may be abridged by blowing on the surface of the metallic mass, which greatly assists in the oxidation and evaporation of all bodies, and particularly of antimony. The purification is completed by means of a little nitric thrown into the crucible, which effectually oxides the remaining antimony. Sometimes the gold is deprived of its usual ductility, which is restored by fusing it with nitre and borax.

PURIFICATION of SILVER, by nitre. The silver is to be first granulated, and then mixed with a fourth part of its weight of dry nitre, an eighth part of potash, and a little common glass, all in powder. This mixture is to be put into a good crucible, two-thirds of which only must be full. This crucible is to be covered with a smaller crucible inverted and the whole subjected to intense heat. Gases which are inflammable escape from the crucible, and when it has been fully burnt it is removed and broken. The silver is found in a button at the bottom covered with green alkaline scoriæ.

PURPLE OF CASSIUS is best made according to the French Pharmacopœia, by dissolving 10 parts of acid chloride of gold in 2,000 parts of distilled water; preparing in another vessel a solution of 10 parts of pure tin in 20 of muriatic acid, which is diluted with 1,000 of water, and adding this by degrees to the gold solution as long as a precipitate is formed. The precipitate is allowed to subside, and is to be washed by means of decantation: it is then filtered and dried at a very gentle heat.

PUTTY. 1. A kind of paste or cement compounded of whiting or soft carbonate of lime and linseed oil, beaten or kneaded to the consistence of dough. In this state it is used by glaziers for fixing in the squares of glass in window frames, &c., and also by house-painters to stop up holes and cavities in wood-work before painting. 2. A powder of calcined tin, used in polishing glass and steel. 8. In *architecture*, a very fine cement. used by plasterers and stone masons, made of lime only.

PUTREFACTION. The spontaneous decomposition of animal and vegetable substances, attended by the evolution of fetid gases. By this process, such substances are reduced either to their original separate elements, or to much more simple compounds. The putrefaction, or putrefactive fermentation of animal substances, is usually attended by more fetid and noxious exhalations than those arising from vegetable products, arising chiefly foom the more abundant presence of nitrogen in the former. The formation of ammonia, or of ammoniacal compounds, is a characteristic of most cases of animal putrefaction, while other combinations of hydrogen are also formed, especially carburretted hydrogen, together with complicated and often highly infectious vapors or gases, in which sulphur and phosphorus are frequently discerned. These putrefactive effluvia are for the most part easily decomposed or rendered innocuous by the agency of chlorine: hence the importance of that substance as a powerful and rapidly acting disinfectant. The rapidity of putrefaction and the nature of its products, are to a great extent influenced by temperature, moisture, and access of air. A temperature between 60° and 80°, a due degree of humidity and free access of air, are the circumstances under which it proceeds most rapidly. Hence the abstraction of the air, and water, or humidity, or its fixation by cold, by salt, sugar, spices, &c., will counteract the process of putrefaction. (*See* FERMENTATION, DECOMPOSITION.)

PUZZOLANA, or PUZZUOLANA. A loose porous volcanic substance or earth of a gray color, deriving its name from Puzzuoli, in Italy, whence it was originally brought. It is found in many other parts of Italy, and generally in the neighborhood of volcanoes active or extinct, from whence it has been thrown out in the form of ashes. It is composed of silicious, argillaceous and calcareous earths, and iron. When mixed with one-third of its weight of lime and water it immediately hardens, forming an admirable water cement.

PYRITES. The sulphurets of copper and iron, commonly distinguished as copper and iron pyrites. The former is the principal ore of copper; the latter is an abundant natural product of a brass-yellow color. When exposed to air and moisture, especially after having been heated, it absorbs oxygen, and yields sulphate of iron, or green vitriol. The term is derived from πυρ, *fire;* either because they sometimes spontaneously ignite, or as being hard enough to strike fire with steel.

PYRO-ACETIC SPIRIT. This liquid was discovered and described by Chenevix long before *pyroligneous spirit* was known. It may be obtained by subjecting to dry distillation the acetates of copper, lead, alkalies, and earths; the liquor which comes over then should be set apart, separated by decantation from the empyreumatic oil, and distilled a second time by the heat of a water-bath. The fine light fluid which now comes over first, is to be rectified along with carbonate of potassa, or chloride of calcium. As pyro-acetic spirit usually retains, even after repeated distillations, a disagreeable empyreumatic smell, like garlic, a little good bone-black should be employed in its final rectification. It is very combustible, and burns with a brilliant flame, without smoke. When treated by chlorine, it loses an atom of its hydrogen, and absorbs 2 atoms of chlorine. It is soluble in water, alcohol, ether, and is not convertible into ether by strong sulphuric acid. It is used for dissolving the resins commonly called gums, with which the bodies of hats are stiffened.

PYROLIGNEOUS ACID has been noticed under acetic acid. It is made by the distillation of wood in close vessels. The retorts are of cast iron, 6 feet long, and 3 feet 8 inches in diameter. Two of these cylinders are heated by one fire, the flame of which plays round their sides and upper surface; but the bottom is shielded by fire-tiles from the direct action of the fire. Two cwts. of coals are sufficient to complete the distillation of one charge of wood; 36 imperial gallons of crude vinegar, of specific gravity 1·025, being obtained from each retort. The process occupies 24 hours. The retort-mouth is then removed, and the ignited charcoal is raked out for extinction into an iron chest, having a groove round its edges, into which a lid is fitted.

When this pyroligneous acid is saturated with quicklime, and distilled, it yields one per cent. of pyroxilic spirit (sometimes called naphtha); which is rectified by two or three successive distillations with quicklime.

The tarry deposit of the crude pyroligneous acid, being subjected to distillation by itself, affords a crude pyro-acetic ether, which may also be purified by redistillation with quicklime, and subsequent agitation with water.

The pyrolignite of lime is made by boiling the pyroligneous acid in a large copper, which has a sloping spout at its lip, by which the tarry scum freely flows over, as it froths up with the heat. The fluid compound thus purified is syphoned off into another copper, and mixed with a quantity of alum equivalent to its strength, in order to form the red liquor, or acetate of alumina, of the calico-printer. The acetate of lime, and sulphate of alumina and potash, mutually decompose each other; with the formation of sulphate of lime, which falls immediately to the bottom.

M. Kestner, of Thann, in Alsace, obtains, in his manufactory of pyroligneous acid, 5 hectolitres (112 gallons imperial, nearly) from a cord containing 93 cubic feet of wood. The acid is very brown, much loaded with tar, and marks 5° Baumé; 220 kilogrammes of charcoal are left in the cylinders; 500 litres of that brown acid produce, after several distillations, 375 of the pyroligneous acid of commerce, containing 7 per cent. of acid, with a residuum of 40 kilogrammes of pitch. For the purpose of making a crude acetate of lead (pyrolignite) he dries pyrolignite of lime upon iron plates, mixes it with the equivalent decomposing quantity of sulphuric acid, previously diluted with its own weight of water, and cooled; and transfers the mixture as quickly as possible into a cast-iron cylindric still, built horizontally in a furnace; the under half of the mouth of the cylinder being always cast with a semicircle of iron. The acetic acid is received into large salt-glazed stone bottles. From 100 parts of acetate of lime, he obtains 133 of acetic acid, at 38° Baumé. It contains always a little sulphurous acid from the reaction of the tar and the sulphuric acid.

Stoltze has ascertained, by numerous experiments, that one pound of wood yields from 6 to 7¼ ounces of liquid products; but in acetic acid it affords a quantity varying from 2 to 5, according to the nature of the wood. Hard timber, which has grown slowly upon a dry soil, gives the strongest vinegar. White birch and red beech afford per pound 7½ ounces of wood vinegar, 1¼ ounce of combustible oil, and 4 ounces of charcoal. One ounce of that vinegar saturates 110 grains of carbonate of potassa. Red pine yields per pound 6¼ ounces of vinegar, 2¼ ounces of oil, 3¾ ounces of charcoal; but one ounce of the vinegar saturates only 44 grains of carbonate of potassa, and has therefore only two-fifths of the strength of the vinegar from the birch. An ounce of the vinegar from the white beech, holly oak (*Ilex*), common ash, and horse chestnut, saturates from 90 to 100 grains of the carbonate. In the same circumstances, an ounce of the vinegar of the alder and white pine saturates from 58 to 60 grains.

PYROLIGNEOUS or PYROXILIC SPIRIT, improperly called naphtha. This is employed, as well as pyro-acetic ether, to dissolve the sandarach, mastic, and other resinous substances, which, under the name of gums, are used for stiffening the bodies of hats. It is described in the article PYROLIGNEOUS ACID, how this spirit is obtained. Berzelius has found that the crude spirit may be best purified by agitating it with a fat oil, in order to abstract the empyreumatic oil; then to decant the spirit, distil it, first with fresh calcined charcoal, and next with chloride of calcium. The pyroligneous spirit, thus purified, is colorless, and limpid like alcohol; has an ethereous smell, somewhat resembling that of ants. Its taste is hot, and analogous to that of oil of peppermint. Its specific gravity, given by Ure, is 0·824. It readily takes fire, and burns with a blue flame, without smoke. It combines with water in any proportion; a property which distinguishes it from pyro-acetic ether and spirit.

PYROLUSITE. A mineralogical term applied by some to the common black or binoxide of manganese, from the facility with which it is resolved by heat into oxygen and a suboxide.

PYROMETER. An instrument for the measurment of temperatures above those which we are able to estimate by the mercurial thermometer.

That of Daniel has superseded that of Wedgewood. It consists of a bar of platina, and a tube of black lead. Its determinations are made by an index, attached to the platina bar, which expands and contracts, and the index traverses a circular scale fixed to the tube, and is invariable when applied to the same objects. Wedgewood's gives the same indications at a low heat long continued, as to great heat suddenly brought in contact, and therefore fails.

Guyton de Morveau presented to the French Institute a pyrometer of platina, which measured high temperatures by the expansion of this refractory metal.

An improvement of this instrument was brought forward by Mr. Daniel in 1821, which consisted of a bar of platina ten one-fifth inches long, and 0·14 inch in diameter. It is placed in a tube of black lead or earthen ware, and the difference between the expansion of the platina bar and the earthen ware tube is indicated on a circular scale. This pyrometer indicates a change of about 7° of Fahrenheit; or, in other words, 1° of Daniel is equal to 7° of Fahrenheit. The following are some of the results obtained by this instrument.

	Daniel.	Fahr.
Boiling point of mercury..	92°	644°
Fusing point of tin	63	441
" " bismuth ..	66	462
" " lead.......	87	609
" " zinc	94	648
" " brass	267	1869
" " silver.....	319	2233
" " copper....	354	2548
" " gold.......	370	2590
" " cast-iron ..	497	3479
Red heat just visible in day-light.............	140	980
Heat of a common fire....	163	1141

Fusing Points of Metals, derived from their Expansions to 212° and 662°, supposed equable.

	From 212° rate.	From 662° rate.	Real Temperature.
Tin	471°	....	442° by Thermometer.
Lead	670	....	612 by Thermometer.
Zinc	848	690° ?	773 by Pyrometer.
Silver.................	2159	2049	1873 by Pyrometer.
Copper	3262	2366	1996 by Pyrometer.
Cast-iron..............	3096	2489	2786 by Pyrometer.

Mr. Prinsep has framed a pyrometer which determines high temperature from the fusing point of different metals, and metallic alloys.

PYROPHORUS. An artificial product, which takes fire on exposure to the air. It is prepared by several methods. Four or five parts of burnt alum are mingled with two of charcoal powder. The mixture is introduced into a vial or matrass. The vial is filled two-thirds, and put into a crucible. The body of the flask is also surrounded with sand, after which the crucible is put into a furnace, and surrounded with red-hot coals. The fire is gradually increased until the flask becomes red-hot, at which temperature it is maintained for about a quarter of an hour. As soon as the vessel is cool enough to be handled, it is taken out of the sand, and the contents transferred into a dry glass, made warm, which must be secured with a glass stopper. Whenever this mixture is poured out in the air, it takes fire.

A pyrophorus may be prepared by mixing three parts of alum with one of wheat flour, and calcining them in a vial, as in the above case.

Tartrate of lead, also on being heated in a glass tube until it becomes converted into coaly matter, gives rise to a beautiful pyrophorus.

The pyrophorus, invented by Doctor Hare, is formed from heating a mixture of three parts lampblack, four calcined alum and eight pearlashes, in a gun-barrel. The mixture is maintained at a cherry-red heat about one hour, or until it ceases to give off inflammable gas at the orifice of the tube, after which it is withdrawn from the furnace, and closely corked from the air. When cold, if poured from the gun-barrel into the air, it immediately glows and takes fire: and more especially if breathed upon, or slightly moistened. This pyrophorus may be preserved in its full activity for a year or more, if well corked up from the air.

PYROTECHNY FIREWORKS. The composition of luminous devices with explosive combustibles, is a modern art, resulting from the discovery of gunpowder.

The three prime materials of this art are, nitre, sulphur, and charcoal, along with filings of iron, steel, copper, zinc, and resin, camphor, lycopodium, &c. Gunpowder is used either in grain, half crushed, or finely ground, for different purposes. The longer the iron filings, the brighter red and white sparks they give; those being preferred which are made with a very coarse file, and quite free from rust. Steel filings and cast-iron borings contain carbon, and afford a more brilliant fire, with wavy radiations. Copper filings give a greenish tint flame; those of zinc, a fine blue color; the sulphuret of antimony gives a less greenish blue than zinc, but with much smoke; amber affords a yellow fire, as well as colophony, and common salt; but the last must be very dry. Lampblack produces a very red color with gunpowder, and a pink with nitre in excess. It serves for making golden showers. The yellow sand or glistening mica, communicates to fireworks golden radiations. Verdigris imparts a pale green; sulphate of copper and sal-ammoniac, a palm-tree green. Camphor yields a very white flame and aromatic fumes, which mask the bad smell of other substances. Benzoine and storax are used also on account of their agreeable odor. Lycopodium burns with a rose color and a magnificent flame; but it is principally employed in theatres to represent lightning, or to charge the torch of a fury.

Fireworks are divided into three classes: 1, those to be set off upon the ground; 2, those which are shot up into the air; and 3, those which act upon or under water.

Composition for *jets of fire;* the common preparation for rockets not more than ¾ of an inch in diameter, is: gunpowder, 16 parts; charcoal, 3 parts. For those of larger diameter; gunpowder, 16; steel filings, 4.

Brilliant revolving wheel; for a tube less than ¾ of an inch; gunpowder, 16; steel filings, 8. When more than ¾: gunpowder, 16; filings, 4.

Chinese or Jasmine fire; when less than ¾ of an inch: gunpowder, 16; nitre, 8; charcoal (fine), 3; sulphur, 3; pounded cast-iron borings (small), 10. When wider than ¾: gunpowder, 16; and nitre, 12; charcoal, 3; sulphur, 3; coarse borings, 12.

A fixed brilliant; less than ¾ in diameter: gunpowder, 16; steel filings, 4; or, gunpowder, 16; and finely pounded borings, 6.

Fixed suns are composed of a certain number of jets of fire distributed circularly, like the spokes of a wheel. All the fusees take fire at once through channels charged with quick matches. *Glories* are large suns with several rows of fusees. *Fans* are portions of a sun, being sectors of a circle. The *Patte d'oie* is a fan with only three jets.

Cascades imitate sheets or jets of water. The Chinese fire is best adapted to such decorations.

Fixed stars. The bottom of a rocket is to be stuffed with clay, and one diameter in height of the first preparation being introduced, the vacant space is to be filled with the following composition, and the mouth tied up. The pasteboard must be pierced into the preparation, with five holes, for the escape of the luminous rays, which represent a star.

Composition of fixed stars:—

	Ordinary.	Brighter.	Colored.
Nitre	16	12	0
Sulphur	4	6	6
Gunpowder meal.	4	12	16
Antimony	2	1	2

Lances are long rockets of small diameter, made with cartridge paper. Those which burn quickest should be the longest. They are charged by hand without any mould, with rods of different lengths, and are not strangled at the mouth, but merely stuffed with a quick match of tow. These lances form the figures of great decorations; they are fixed with springs upon large wooden frameworks, representing temples, palaces, pagodas, &c. The whole are placed in communication by *conduits*, or small paper cartridges, like the lances, but somewhat conical, that they may fit endwise into one another to any extent that may be desired. Each is furnished with a match thread fully 1½ inches long, at its two ends.

Composition for the *white lances:* nitre, 16; sulphur, 8; gunpowder, 4 or 8. For a *bluish-white:* nitre, 16; sulphur, 8; antimony, 4. For *blue lances:* nitre, 16; antimony, 8. For *yellow:* nitre, 16; gunpowder, 16; sulphur, 8; amber, 8. For *yellower* ones: nitre, 16; gunpowder, 16; sulphur, 4; colophony, 3; amber, 4. For *greenish* ones: nitre, 16; sulphur, 6; antimony, 6; verdigris, 6. For *pink lances:* nitre, 16; gunpowder, 3; lampblack, 1.

The Bengal flames rival the light of day. They consist of, nitre, 7; sulphur, 2; antimony, 1. This mixture is pressed strongly into earthern porringers, with some bits of quick match strewed over the surface. These flames have a fine theatrical effect for conflagrations.

Revolving suns are wheels upon whose circumference rockets of different styles are fixed, and which communicate by *conduits*, so that one is lighted up in succession after another. The composition of their common fire is, for sizes below ¾ of an inch: gunpowder meal, 16; charcoal, not too fine, 3. For larger sizes: gunpowder, 20; charcoal, not too fine, 4.

For *fiery radiations:* gunpowder, 16; yellow micaceous sand, 2 or 3. For *mixed radiations:* gunpowder, 16; pit-coal, 1; yellow sand, 1 or 2.

The *waving or double Catharine wheels* are two suns turning about the same axis in opposite directions. The fusees are fixed in obliquely, and not tangentially to their peripheries. The wheel spokes are charged with a great number of fusees; two of the four wings revolve in the one direction, and the other two in the opposite; but always in a vertical plane.

The rockets which rise into the air with a prodigious velocity are among the most common, but not least interesting fireworks. When employed profusely, they form those rich volleys of fire which are the crowning ornaments of a public fête. The cartridge is similar to that of the other jets, except in regard to its length, and the necessity of pasting it strongly, and planing it well; but it is charged in a different manner. As the sky-rockets must fly off with rapidity, their composition should be such as to kindle instantly throughout their length, and extricate a vast volume of elastic fluids. To effect this purpose, a small cylindric space is left vacant round the axis; that is, the central line is tubular. The composition of sky-rockets is as follows:—

When the bore is	3-4 of an inch:
Nitre	16
Charcoal	7
Sulphur	4
Brilliant Fire.	
Nitre	16
Charcoal	6
Sulphur	4
Fine steel filings	8
Chinese Fire.	
Nitre	16
Charcoal	4
Sulphur	8
Fine borings of cast-iron	8 coarser

The cartridge being charged as above described, the *pot* must be adjusted to it, with the *garniture;* that is, the serpents, the crackers, the stars, the showers of fire, &c. The pot is a tube of pasteboard wider than the body of the rocket, and about one third of its length. After being strangled at the bottom like the mouth of a vial, it is attached to the end of the fusee by means of twine and paste. These are afterwards covered with paper. The garniture is introduced by the neck, and a paper plug is laid over it. The whole is inclosed within a tube of pasteboard terminating in a cone, which is firmly pasted to the pot. The quick-match is now finally inserted into the *soul* of the rocket. The rod attached to the end of the sky-rockets to direct their flight is made of willow or any other light wood.

The *garnitures* of the sky-rocket pots are the following:—

1. *Stars* are small, round, or cubic solids, made with one of the following compositions, and soaked in spirits. *White stars,* nitre, 16; sulphur, 8; gunpowder, 8. Others more vivid consist of nitre, 16; sulphur, 7; gunpowder, 4.

Stars for golden showers, nitre, 16; sulphur, 10; charcoal, 4; gunpowder, 16; lampblack, 2. Others yellower are made with nitre, 16; sulphur, 8; charcoal, 2; lampblack, 2; gunpowder, 8.

The *serpents* are small fusees made with one or two playing cards; their bore being less than half an inch. The *lardons* are a little larger, and have three cards; the *vetilles* are smaller. Their composition is, nitre, 16; charcoal, not too fine, 2; gunpowder, 4; sulphur, 4; fine steel filings, 6.

The *cracker* is a round or square box of pasteboard, filled with granulated gunpowder, and hooped all round with twine.

Roman candles are fusees which throw out very bright stars in succession. With the composition (as under) imbued with spirits and gun-water, small cylindric masses are made, pierced with a hole in their centre. These bodies, when kindled and projected into the air, form the stars. There is first put into the cartridge a charge of fine gunpowder of the size of the star; above this charge a star is placed; then a charge of composition for the Roman candles.

Roman candles, nitre, 16; charcoal, 6; sulphur, 8. When above ¾ of an inch, nitre, 16; charcoal, 8; sulphur, 6.

PHOSPHORITE, **Apatite.** *Native Phosphate of lime, natural Bone-earth.* Under these various terms, nearly synonymous, are comprehended a variety of mineral which is rather sparingly diffused, and has lately become of considerable value in an agricultural point of view, as a substitute for bone-dust and guano, and in a manufacturing point of view, as the crude material from which phosphorus may be readily obtained. *Apatite* is a mineral which crystallizes in the regular six-sided prism usually terminated by a six-sided truncated pyramid; it has usually a yellowish green tint, and is translucent. In hardness it ranks above fluorspar, and below feldspar. It is a compound of phosphate of lime with fluoride of calcium. It principally occurs in primitive rocks, and is found in the tin mines of Cornwall, England, in those of Bohemia, Moravia, and Saxony, and from the rocks of St. Gothard. Apatite is found in granitiform rocks in New York, New England, and New Jersey, in isolated crystalline masses. Its color is no distinguishing test, as it assumes the tint of the neighboring rocks, being thus calculated to lead to deception as to its nature from whence it has derived its name (*deceitful* Gr.) Those of a bluish or green color may easily be mistaken for beryls. Some are colorless, violet, or lilac, and if not distinctly crystallized may be mistaken for fluorspar. The specific gr. of the crystals of apatite is 3·1. They are soluble in nitric acid, and become phosphorescent when heated. Asparagus stone is of a green-yellow color, found in the Tyrol, where the crystals are imbedded in talc. Moroxite is a name given to bluish-green crystals from Arndal, Norway. It is, however, uncommon to find it in large masses as well defined crystals. It is more common in the fibrous and amorphous condition. In the latter state it is known as phosphorite. This mineral is opaque, of a white or yellow-white tint, of a feathery structure, with numerous small cavities. This variety is massive, and at Lagrosso, in Estremadura, Spain, forms entire hills: it is there used as a building stone. In Hungary phosphorite occurs of a loose earthy texture in thin beds. In this country, besides the localities of crystalline apatite, there are two locations where phosphate of lime occurs in abundance; one of these is near Crown Point, on Lake Champlain, where Dr. Emmons discovered it in *situ*. He has described it as being in beds of almost unlimited quantity, and of a great degree of purity, yielding as much as 93 per cent of phosphate of lime on analysis; the gangue rock is serpentine, which communicates a green tint to the phosphorite of that locality. The other point where phosphorite is found, is in Morris County, New Jersey, near Pimple Hill, where it has been found as a vein, or dyke, running through a ferruginous feldspathic rock, which here tinges the phosphorite brownish red. This vein is semi-crystalline in some spots, and of considerable purity. The extent of this vein has been traced in length for two miles, and it is stated to have a breadth of eight feet: five feet below the surface, it widens on quarrying down. These are among the largest beds of phosphorite known, and are of incalculable value either for art, or for agriculture.

The analysis of the New Jersey bed of phosphorite, with the gangue or feldspathic rock by which it was surrounded, made by the Editor, yielded the following results in 100 parts.

	1	2	3
Phosphate of lime - -	5·8	2·6	93·6
Alumina and oxide of iron	2·5	1·0	—
Lime - - - - -	0·9	2·2	3·6
Magnesia - - - - -	0·3	0·1	0·2
Chlorine - - - - -	1·0	0·7	2·6
Fluorine - - - - -	2·3	traces	—
Alkaline salts - -	—	·1	—
Silica - - - - -	87·2	93·3	—
	100·	100·	100·
Specific gravity - -	2·53	2·31	3·

No 1, was a mass of rhomboidal quartz with mica, and tinged with oxide of chrome.

No. 2, was the feldspathic gangue stone in the immediate vicinity.

No. 3, apatite from the vein. This sample, heated with sulphuric acid, gave off no hydrofluoric acid vapors, showing the absence of fluorspar, which usually accompanies phosphate of lime. In its place, however, was substituted chloride of sodium, giving it some resemblance to the variety described by H. Rose as clor-apatite. The mineral found in New Jersey is very brittle, easily pulverized, and might be readily ground into powder, and made marketable as a substitute for bone-dust, of which it has precisely the mineral composition. Phosphorite, as a mineral, is generally found in primary rocks, and in contact with serpentine. Phosphate of lime has however been found in England and Europe (continental), in other situations, as in beds of clay, of the upper, secondary, and tertiary periods. Captain Ibbotson has found phosphate of lime in the chloritic marl of the Isle of Wight. This is geologically the upper green sand-bed immediately under the chalk-marl. In the lower part of the green sand-bed, ammonites and scaphites occur mixed with coprolitic masses, rich in phosphate of lime; the coprolites are now understood to be the fossil excretions of the Saurian tribes. Mr. Nesbitt has found in the chalk-marls phosphate of lime to the extent of two or three per cent. Nodules (coprolites), from the *gault*, near Maidstone, England, have furnished twenty-eight per cent of phosphate of lime. The green sand, and upper secondary beds of this country, have not been examined sufficiently to determine whether it exists or not. Mr. Rogers, in his geological report of the State of New Jersey, looks upon the richness, as a manure, of the green sand to be due to the potash present in it, of which substance, in some cases, he obtained so much as seventeen per cent. Other analyses, by different chemists, have not supported this large amount of alkali, and it is probable that some of its fertility may be due to the presence of phosphate of lime.

QUARRYING, is the extracting stones from strata lying in regular layers, and performed by the pick, wedge, lever, or iron crow, and hammer. When not in layers, or in rocks, harder than sandstone, recourse is had to blasting, for which Hancock's fuses are a very successful modern invention.

QUARTATION. In metallurgy, the separation of silver from gold by means of nitric acid. To extract the whole of the silver from gold by the action of nitric acid, it is necessary that there should be at least three parts of silver to one of gold, otherwise the gold protects the silver from the action of the acid; so that, in thus separating these precious metals, it is customary, where gold greatly predominates, to add silver till it constitutes at least three fourths of the alloy.

QUARTER. The fourth part of any thing. As a term of weight, it denotes the fourth of a hundred weight, or 28 pounds; as a dry measure, it signifies the fourth of a chaldron.

Quarter. The after part of the ship's side. *On the quarter*, implies the bearing or position of an object seen between abaft and abeam.

QUARTZ. The name given by mineralogists to numerous varieties of rock crystals, the native oxides of silicium, called also silicious or flint earth, and silicic acid. Quartz is most comprehensive in its varieties. It occurs both crystallized and massive, and in both states is most abundantly diffused throughout nature, and is especially one of the constituents of granite and the older rocks. It generally occurs in hexagonal prisms, terminated by hexagonal pyramids. It scratches glass readily, gives fire with steel, becomes positively electrical by friction, and two pieces when rubbed together become luminous in the dark. The colors are various, as white, gray, reddish, yellowish or brownish, purple, blue, green. Horn stone, amethyst, siderite, agate, avanturine, flint, opal, chalcedony, onyx, sardonyx, and jasper are varieties. (See LAPIDARY.)

QUASSIA. A name formed in remembrance of a negro named Quassy, who first made known the medicinal virtues of one of the species. A genus of South American tropical plants, consisting of trees; nat. order Simarubaceæ. The wood of two species is known in commerce by the name of *Quassia*; *Q. amara*, a native of Surinam; and *Q. excelsa* (*Picræna excelsa*, Lindley), a native of Jamaica. Both kinds are imported in billets, and are inodorous, but intensely bitter, especially the Jamaica Quassia. The active principle has been termed quassite, a neutral body readily soluble in alcohol. Quassia is a pure and simple bitter, possessing marked tonic properties, and hence useful in debility, particularly of the stomach and muscular system. It is generally given in the form of infusion. An infusion of quassia sweetened with sugar is useful to destroy flies. The wood of *Q. excelsa* is employed by fraudulent brewers in adulterating beer, as a substitute for Hops.

QUERCITRON. 1. The *Quercus nigra*, *black oak*, or *dyer's oak*, which grows from Canada to Georgia, and west to the Mississippi. It frequently attains the height of seventy or eighty feet, and is one of the largest trees of the American forests. 2. The bark of the *Quercus nigra*, or American oak; it is a highly valuable dye-stuff, and is used in the production of some of the most durable yellows. It was first brought before the public by Dr. Bancroft. Although this oak affords a yellow color, yet it is not the *yellow oak*, that name being commonly applied to *Quercus Castanea*. (*See* OAK.)

QUICKLIME. Caustic lime. Limestone freshly burnt, and deprived by that means of its carbonic acid. *See* LIME.)

QUICKSILVER. (*See* MERCURY.)

QUINIA, or QUININE. An alkaline base obtained from yellow bark; the *Cinchona cordifolia*. This substance, combined with sulphuric acid, forms the *sulphate of quinia*, which is now so extensively used as a medicine, and as a substitute for the various forms of Peruvian bark. To obtain quinia, bruised yellow bark is boiled in repeated portions of water, acidulated by sulphuric acid, till all its soluble matters are extracted; a little excess of quicklime is then added to the strained decoction, and the precipitate which is formed is collected, washed, and carefully dried; it is then digested in alcohol, which takes up the quinia, and from which it may be obtained in the form of a yellowish uncrystallizable substance by careful evaporation. It is dissolved in dilute sulphuric acid, and the sulphate of quinine or quinia, crystallizes from its concentrated solution in fine silky prisms, which effloresce on exposure to air. Sulphate of quinia is difficultly soluble in water, and intensely bitter. It is more strictly a *disulphate of quinia*.

Cinchona exists in all barks to some extent; and there are several modes of separating the quinine from the cinchona, viz:—

1. By evaporating the alcoholic solution on cooling, the cinchona crystallizes, while the quinine remains dissolved.

2. Digestion in ether dissolves the quinine, and leaves the cinchona.

3. We may supersaturate slightly the two bases with sulphuric acid. Now as the supersulphate of quinine is sparingly soluble, the liquor need only to be evaporated to a proper point to crystallize out that salt, while the supersulphate of cinchona continues in solution with very little of the other salt. Even this may be separated by precipitating the bases, and treating them, as above prescribed, with alcohol or ether.

One pound of bark rarely yields more than two drachms of the bases. One pound of red bark afforded, to Pelletier and Caventou, 74 grains of cinchona, and 107 grains of quinine.

Quinine is composed of 75·76 carbon, 7·52 hydrogen, 8·11 azote, and 8·61 oxygen.

The salts of quinine are distinguished by their strong taste of Peruvian bark, and if crystallized, by their pearly lustre. Most of them are soluble in water, and some also in ether and alcohol. The soluble salts are precipitated by the oxalic, gallic, and tartaric acids, and by the salts of these acids. Infusion of nutgalls also precipitates them.

The sulphate of quinine is the only object of manufacturing operations. Upon the brownish viscid mass obtained in any of the above processes for obtaining quinine, pour very dilute sulphuric acid, in sufficient quantity to produce saturation. The solution must be then treated with animal charcoal, filtered, evaporated, allowed to cool, when it deposits crystals. 1000 parts of barks afford, upon an average, 12 parts of sulphate. The sulphate of cinchona, which is formed at the same time, remains dissolved in the mother-waters.

RACEMIC ACID. An acid found, together with the tartaric acid, in the tartar obtained from certain vineyards on the Rhine. It is the *paratartaric acid* of Berzelius. It is less soluble in water than tartaric acid, and differs in the form of its crystals and in its salts; yet it appears to be *isomeric*, and to have the same equivalent with the tartaric acid.

RAILING. A fence or barrier made of posts and rails. The most ordinary fence of this description in the country is formed of wooden posts let in the soil, so as to stand upright, to which are nailed or mortised horizontal wooden rails, one above another, at such a distance as to prevent domestic animals from penetrating through them. In some cases one horizontal rail is fixed to the posts near the ground, and another near the top of the post, and the interval between them is rendered impervious to cattle by upright rails nailed to the top and bottom horizontal rail. Iron railings are generally formed in this manner.

RAILROADS or RAILWAYS. Roads constructed of tracks of iron called *rails*, on which the wheels of carriages roll, and to which they are confined by ledges or *flanges* raised either on the rail or on the tires of the wheels.

History of Railways. About the middle of the 17th century, the transport of coals from the pits to the harbor was effected in the coal districts of Northumberland and Durham by laying down parallel tracks of timber with a horse-path between them, the wheels being confined upon the beams or rails of timber by ledges or flanges projecting from the inside of the tire of the wheels. These timber rails were constructed in pieces of about six feet long with a section of about four inches square; they were supported on pieces of timber called *sleepers* laid at right angles to them transversely on the road. These sleepers were laid at about two feet apart, so that each pair of parallel rails was supported by three sleepers; besides giving support to the rails, these sleepers also had the effect of maintaining the rails in gauge, or in keeping them at a fixed distance asunder. The rails were fastened to the sleepers by pins driven quite through the rails, and half way through the sleepers; to preserve the uniformity of the upper surface of the rail, these wooden pins were planed off at the top.

The necessity of giving room for the flanges of the wheels, running as they did below the surface of the rail, and the small depth between the surface of the rail and the sleeper, rendered it impossible to protect the sleepers effectually from the action of the horses' feet by any covering of gravel or other material. The sleepers were consequently subject to be worn and destroyed. The rails, also, being worn by the action of the wheels still more rapidly than the sleepers, required to be frequently replaced; and, each new rail being pinned down to the same sleeper, the ends of the sleepers were gradually perforated by so many holes that the sleepers were weakened, and required to be soon replaced. These defects were remedied by the adoption of the double timber railway, which consisted in laying upon the surface of the timber rails, above described, additional rails of timber of equal scantling, attached to the lower rails by wooden pins, passing quite through the upper and half through the lower rails, in the same manner as the lower rails themselves were attached to the transverse sleepers. This change was attended with many advantages. Besides the increased strength given to the rails by the double timbers, the depth of the sleepers below the upper surface of the superior rail, allowed the sleepers to be protected from the action of the horses' feet by covering them with broken stones, gravel, or other road materials. The structure of rails and sleepers also being stronger and more weighty, and held down by the road material with which the sleepers were covered, allowed a packing or ballasting to be driven under the rails, so as to give greater stability and firmness to the road. Another advantage obtained by this arrangement was, that when the superior rails were worn by the action of the wheels, they could be replaced by new ones without disturbing the inferior rails; and as the places of the joints, and those at which they were attached by pins to the inferior rails, could be varied at pleasure, the pin-holes made in the inferior rails would not come in the same place, or near each other, so as injuriously to weaken the latter.

The next improvement consisted in the addition of a plate or bar of iron, about two inches broad and half an inch thick, laid along the upper surface of the superior rail, and attached to it by nails or iron pins countersunk in it. The wheels of the carriages ran upon this iron rail, which formed a more durable surface than that of the wood. In our country railways of this construction are still in very general use. They are recommended by the abundance and cheapness of timber, and the comparative high cost of iron. Such a road is tolerably efficient where the traffic is light, and can therefore be resorted to in localities and circumstances in which an adequate return could not be obtained for the capital necessary for the construction of these timber railways. On this continent many other improvements have been introduced, more especially in the substructure of the road. In laying out the roadway for the reception of the rails, two parallel trenches are cut along the line of way corresponding to the distance between the rails, and transverse trenches at right angles to these are cut to receive the sleepers: these trenches are respectively bottomed with a ballasting of broken stone, on which the rails and cross-sleepers rest. This basis answers the double purpose of a firm and durable support for the road and an effectual means of drainage. The scantling of the timbers used for the rails is usually six inches in width by ten inches in depth: they are attached to the sleepers, so as to be at once kept from springing from them and from altering their gauge, by the following means: A notch is cut in the sleeper corresponding to the size and form of the rail; and the rail, at the place where it is let into the sleeper, is formed with a vertical surface on the outside, and a levelled surface on the inside, increasing in width downwards. When let into the notch of the sleeper, the levelled part of the rail is forced into the corresponding cavity of the notch by a wedge driven between the outside edge of the rail and the outer surface of the notch.

Until within a recent period, stone blocks were universally regarded as the best permanent support for the rails wherever they could be laid upon a solid and durable foundation, and wooden sleepers were only resorted to as temporary supports, to be ultimately superseded by stone blocks whenever the foundation of the road should be properly consolidated. Opinion has, however, undergone some change on this subject, and wooden sleepers are now sometimes used in preference to stone blocks for permanent purposes:

whether they will prove economical, when submitted to the trial of a long period of time, experience alone can decide.

The chairs, which are the immediate supports or props on which the rails rest, are attached to the centre of the upper surfaces of the blocks in the following manner: Two holes are drilled in the blocks to a sufficient depth, about 2 inches in diameter, into which plugs of oak or other hard wood are driven; holes are then bored in these, 3-8ths of an inch in diameter, corresponding in position with two holes in the chair of cast iron, which is to support the rail. Iron pins of half an inch in diameter are then driven through the holes in the chairs into the holes in the block, a piece of patent felt being placed between the chair and the block; and the chair is thus firmly fastened to the block.

The chairs are formed of cast-iron, formed with a cavity corresponding to the magnitude and form of the rail: they vary very much in their size and form, according to the opinion or judgment of the engineer.

A great variety of expedients have been resorted to to maintain the rail fixed in its position in the chair. Pins and wedges of iron were first used of various forms, and applied in various ways. These, however, have now been very generally superseded by the simple contrivance of a wooden block or wedge, driven in between the side of the chair. These wedges are prepared by previously passing them through a hydrostatic press, so as to harden them by exposing them to a severe pressure. Besides affording a very effectual fastening to the rail in the chair, these wedges, from the nature of the material, soften the jar which attends the transition of the wheels over the chairs.

The distance between the bearings or chairs has also been subject to change. The necessary strength or weight of the rail will evidently depend on this distance; the greater the distance between the props, the greater must be the strength of the rail; and, so far as regards the expense, the engineer has to balance the cost of heavier rails against the saving effected by a diminished number of blocks and chairs. But, independently of the consideration of expense, the effect upon the carriages and engines is to be considered. Between chair and chair, a slight flexure of the rail takes place, and the wheels have consequently to pass over a series of eminences, so as to give to the carriages a pitching motion, the intervals and degree of which must depend conjointly on the strength of the rails and the distance between the chairs.

The least distance between the chairs now used is 3 feet, and the greatest 5 feet; 50 lb. rails are very generally used on 3 feet bearings; 65 lb. rails on 4 feet bearings and 75 lb. rails on 5 feet bearings.

Rails made entirely of malleable iron were first employed at the collieries near Edinburgh; and were formed of rectangular bars, which presented too small a surface for the wheels, or otherwise require more materials than it would be consistent with economy to employ. To obviate this difficulty, a patent was obtained by Birkenshaw, of Bedlington, Eng., for an improved form, which consists in giving the bar the form of a triangular prism. The chief advantage of wrought iron rails is the reduction of the number of joints and the difficulty of making cast-iron rails perfectly even at the joints. Edge rails are best adapted for permanent works, and they are of such a nature that ordinary carriages cannot be employed upon them; but on any railway where such carriages can be used they must do more injury to the surfaces of the rails than will be equivalent to the advantage of suffering them to travel on them.

Tram-ways differ from the preceding in having the guiding flanch upon the rails, instead of being fixed upon the wheels of the carriages. It affords the advantage of employing such carriages as can be used where there are no rails. The tram-rail is exceedingly convenient for temporary uses, and, in its ordinary form, it is much used in quarries, in mines, in forming new roads, in digging canals, and in conveying large stones for buildings, and other purposes. Tram-rails are very weak, considering the quantity of iron in them, and in some works it has been found necessary to strengthen them, by adding a rib on the under side.

The usual length of a one-tram plate is three feet; the flanch is one and a half inch high; the sole, or bed, three and a half or four inches broad, and three-fourths of an inch thick; but these dimensions are varied, according to circumstances: the most approved weight has been 42 lbs. for each plate. The ends from which the plugs project, and on which the tenons and notches are made, should be a quarter of an inch thicker than the other parts of the plate

By this method, the wheels of wagons cannot be obstructed by the heads of the nails rising above the surface, and the blocks are not disturbed by fixing the plates.

Turn-outs are made by means of a movable or switch-rail, at the angle where the turn-out track branches from the main one. This rail is two or three feet, more or less, in length, and one end may be moved over that angle, and laid so as to form a part of the main track, or the turn-out track. The switch-rail is usually moved by the hand, so as to form a part of that track on which the wagon is to move.

The principal consideration, in regard to the carriages, relates to their bearings on the axle and the rim of the wheel. The rule given by Wood, as to the bearing on the axle, is, that, in order to produce the least friction, the breadth of the bearing should be equal to the diameter of the axle at the place of bearing. This diameter must be determined by the weight to be carried; and the breadth of the bearing will accordingly vary with it. The objection to the plate-rail is, that the breadth of the bearing of the rim of the wheel upon such a rail causes an unnecessarily additional friction; and the resistance to the wheel is increased in consequence of the greater liability of such a rail to collect dust and other impediments upon its surface. The edge-rail is preferable in these respects; but, at first, these rails were liable to one difficulty, in consequence of their wearing grooves in the rim of the wheel, so that the friction is continually increasing, and the wheel so becomes unfit for use. To remedy this defect, the rims are case-hardened, or chilled by rolling them, when hot, against a cold iron cylinder. Wheels so case-hardened are found to be subject to very little wear.

It has been found, in practice, that, for the ordinary inclinations of railroads, 30 feet per mile, the wheels may be so constructed as to move a train of wagons by their mere adhesion to the rails. The inclination which can be so overcome must evidently depend on the kind of surfaces of the rim of the wheel and the rail, the weight bearing upon the wheels, the weight to be moved, and the resistance from the friction of the train of wagons; so that no precise rule can be given that shall be applicable to roads and wheels of different materials and construction.

Curves on Railways.—With a view to insure the public safety, the British legislature has generally required that no curve shall be allowed upon a main line with a less radius than one mile: the exceptions to this are where one railway passes into another; and at the termini, or the entrance of depots or stations. In such situations the trains must slacken their speed, and therefore a sharp curve is attended with less danger. It has appeared, however, that these restrictions upon the radii of curves have been more stringent than safety requires. In a course of experiments made by Dr. Lardner, it has been established that curves of a mile radius produce no sensible increase of resistance at the usual speed of railway trains, and therefore curves of considerably less radius may be traversed at that speed without danger. There is no legislative restriction on the subject in our country, where the radius of the curve is sometimes very short.

Resistance of Air to Railway Trains.—Until very recently, it has been considered by engineers that the resistance to railway trains was almost entirely due to friction and mechanical effects, and that that part of the resistance which depends on the atmosphere formed so inconsiderable a portion of the whole that it might be disregarded in practice. The result of a course of experiments, made within the last two years, by Dr. Lardner, have, however, indicated a serious amount of resistance due to the air. If Dr. Lardner's conclusion shall be further confirmed, the great expense attending the maintenance of very high speed on railways, and the improbability of attaining in the ordinary work of a line the extraordinary velocity which some persons now contemplate, will be apparent.

Of the Formation and Construction of Railways.—Whatever be the moving power to be used for the transport of loads upon a railway, its force must be proportioned to the average resistance of such loads, and it must be capable of varying its energy to the same extent as that resistance is subject to variation. The great perfection which has been attained in the construction of the rails, and in the methods of fixing them in their position upon the road, is such that the resistance offered to the tractive power by loads moved on a straight and level railway may be regarded as practically uniform, so that the moving power by which a load is transported at a given speed on a straight and level line of railway is subject to a resistance as unvaried and as uniform as any to which moving powers are usually submitted in any of the processes of art; but as the amount of resistance to the tractive powers upon a straight and level railway is diminished by the perfection thus attained in the construction of the road, so, in the same degree, is any resistance produced by a departure from a perfect level more sensibly felt. Thus, if the resistance to the moving power on a straight and level railway, by a load moved at a given speed, be equal to the 250th part of the load, an acclivity which would rise at the rate of one foot in 250, or nearly at the rate of 20 perpendicular feet in a mile, would produce a resistance to the moving power by reason of the ascent alone, equal to a 250th part of the load, and therefore equal to the resistance of the moving power would sustain on a level line. It follows, therefore, that under such circumstances, in drawing a load up such an acclivity, the moving power would have to overcome twice the resistance opposed to it on a level; for the same causes which produce on a level a resistance amounting to the 250th part of the load equally produce this resistance in ascending the acclivity, in addition to which there would be an equal amount of resistance due to the ascent. If, therefore, under such circumstances, the moving power were required to draw the load up the acclivity at the same speed as that at which it drew it on the level, the machine exerting that power must be endowed with properties in virtue of which it is capable of varying its energy, without injury to its structure, in the proportion of two to one.

With reference to horse and steam-power, Anderson observes, that a wagon-horse with ease, under favorable circumstances. draws 20 tons. Fulton says, that five tons to a horse is the average work on railways, descending at the rate of three miles per hour; and one ton upwards with the same speed. Telford observes, that on a railway laid with a declivity of 50 feet in a mile, one horse will readily take down wagons containing 12 to 15 tons; and bring back the same wagons with four tons. Wilkes states, that a horse drew down the declivity of an iron road, 5 inches in 16 yards, 21 carriages or wagons, laden with coals and timber, weighing 35 tons, and the same horse, up this declivity drew 6 tons with ease. On a different railway, one horse drew 21 wagons of five cwt. each, which, with their loading of coals amounted to 48 tons 8 cwt., down the declivity of 1 inch in three yards; and he afterwards drew 7 tons up the same; the hundred weight being 120 lbs.

Sylvester states that a moving force, which will give the velocity of 5 miles an hour, or 22 feet in 3 seconds, will be performed *down* a plane, 1 inch in 9 yards, or 1 in 324, by the engine making 45 strokes per minute (the circumference of the wheel being nine feet), with a pressure of 9·7 lbs. upon an inch of each of the two cylinders, the area of each being 63·6 square inches. The weight of the engine and 16 wagons is equal to 154,560 lbs., nearly 70 tons.

If the same weight, at that speed, had to move on *a dead level*, and acquired the same velocity in one minute as before, the moving force would require to be 1781 lbs., which would require a pressure of 13·7 lbs. upon one inch. But after the speed is obtained, it will require only 7 lbs. to keep it moving at the same rate.

If the same load were required to move *up* the plane, it would require a moving force of 2328 lbs., or a pressure upon every square inch of 18·3 lbs. And this velocity would be kept up by a constant pressure of 1447 lbs., which will be 11·2 lbs. upon every inch of the piston.

When the engine is required to travel at the rate of nine miles per hour, the force necessary to overcome the weight 154,560 lbs. will be for the first minute, when the engine is travelling on a level, 2890·81 lbs.; when moving down the plane 2461·61 lbs.; and, when moving up the plane 3320·01 lbs. But that, when the velocity is attained, a force that will balance the friction is sufficient to keep up the required velocity. This force is, for travelling on a level, 900 lbs.; for moving down the plane, 471 lbs.; and for moving up the plane 1329 lbs.

A *boat* weighing with its load 15 *tons*, *and a wagon of the same weight*, the one on a canal and the other on a railway, would be impelled at the following rates, by the following quantities of power—in pounds and in horse-power—reckoning one horse equal to 180 lbs.

Canal.

Miles per hour.	In pounds.	Horse power.
2	33	0·2
4	133	0·66
6	300	1·75
8	533	3·
12	1200	7·
16	2133	12·
20	3325	18·

Railway.

In pounds.	Horse power.
100	0·5
102	0·5
105	0·5
109	0·5
120	0·66
137	0·75
158	1·

The force required to keep a given weight in motion does not vary with the velocity: thus, a force of 14 lbs. was found to overcome friction, and keep in motion an empty coal-wagon, weighing 23·25 cwt. on a railroad; but that, on doubling the velocity, no more force was required. Further, on increasing the weight, or load, the power required to overcome the friction, and keep the wagon in motion, did not increase in similar proportion, but up to 76·25 cwt. was about 1-14th less.

The following is a summary of railway communication in Europe:—

From an analysis of railroads in Great Britain and Ireland, it appears that the number of miles of railroad open for use, on the 30th of June, 1850, was 5,447. The number of passengers conveyed during the preceding half year was 28,761,695. The number of persons killed on the railroads during that period was 86, and of persons injured 75. Of the persons killed, 12 were passengers, five of whom were killed from causes beyond their own control, and seven in consequence of their own misconduct or want of caution. Of the other persons killed, 51 were persons in the employ of the railway companies or of contractors, and 21 were trespassers or persons in no way connected with the railroads, who lost their lives in consequence of improperly crossing or standing on the tracks.

Next to Great Britain, France is the nation which has the most extensive line of railways. Of these, the chief are the St. Etienne Andrezieux, the Roane and Andrezieux, Lyons and St. Etienne, Paris and Versailles, the Epinac, Paris and Havre, Paris and Lyons, Paris and Strasburg, Calais and Paris, the Orleans, &c., &c.

Germany began to experience the luxury and benefit of fast and comfortable riding in the year 1848, by constructing a railroad, of which eighty miles (more than 360 English miles) were completed in that year. At the beginning of 1850, there had been added 840 German miles more to the length, so that there were then more than four thousand English miles of railroad opened for passengers in that country. Add to these both tracks of the Maine Weser line, from Cassel to Frankfort, we have nearly fifty English miles farther. Of the aggregate, over fifteen hundred miles belong to the different governments.

Prussia owns an extent of 840 German miles, or 2,025 United States miles; Austria, 187; Bavaria, 82¼; Saxony, 55¼; Hanover, 48; Baden, 52; Electorate of Hesse, 83; Wurtemburg, 25; Mechlenburg Schwerin, 19; Anhalt, 12; Brunswick, 11¼; Saxe Weimar, 10. In Austria there are 700 miles of railway, and 248 miles being constructed. All the remaining States of Germany have about 1,148 miles.

The Wurtemburg railroads, and the Budweiz-Linz-Gmunder horse line, are quite isolated. The upper Rhenish railroad system, which comprehends the Baden government line, the Maine Neckar line, the Palatinate Ludwig's line, the Taunus line, and the lines from Frankfort to Offenbach, Hanau, and Friedburg, is separated from the large North German system of roads by the unbuilt portion between Friedburg and Marburg, as the Bavarian lines are separated by the tract from Plauen to Reichenbach, and the Austrian southern line by the tract from Glognitz to Muertzenschlag, (over the Sommering.) Forty one joint stock companies own the private lines, and their funds amount to one hundred and fifty-eight and a half million thalers. To this other loans should be added, of sixty-two and a half millions.

Major Brown, our countryman, the consulting railroad engineer of the Emperor of Russia, states in a letter, that the Emperor has determined, as soon as the season will allow, to commence the projected railroad from St. Petersburgh to Warsaw, the surveys for which were made in 1848. Major Brown will, by his position, have the chief superintendence. The distance in this instance to run is from 750 to 800 of our miles, and stretching, for the most part, through an inhospitable tract of country, intersected by many rivers, broad morasses, and lowlands.

The railroad from St. Petersburgh to Moscow, of which our talented countryman, Major Whistler, was chief engineer when he died, is now nearly finished. It is 421 miles long.

In 1830 there were only thirty miles of

locomotive railway in the world, now there are no less than 18,000 miles. America has no less than 8,680 miles, and will soon have 10,000 in operation. Massachusetts alone has more than 1,000, and Pennsylvania 1,200. In 1836 there were only 15 miles of railroad in the State of New York, now there are about 2,283.

The entire amount of capital invested in railway communications in all the countries of the world, is estimated at three hundred and sixty-eight millions and a half. Upwards of 18,656 miles of railway have been constructed. The capital to be invested in 7,800 miles in progress, will amount to nearly $147,000,000.

The total extent would then be 26,450, miles, which is more than would surround the globe. So great is the amount of railway mileage in Great Britain, that it is calculated 27 out of every hundred miles in the world are in the British isles. Among the projected lines of the U.S. are two stupendous lines, one from Cincinnati to St Louis, to cost $5,000,000; and another from Lake Michigan or the Mississippi to the Pacific Ocean, to cost over $60,000,000, for a distance of more than 2,000 miles. Besides these, Ohio, Pennsylvania, Indiana, Illinois, and, indeed, almost every State has various routes surveyed and in contemplation.

The Erie Road is the longest in the world—467 miles. That between Moscow and St. Petersburg, in Russia, is next in length, being 420 miles. The Russian government is about beginning a road from Warsaw to St. Petersburgh, a distance of more than 700 miles, of which T. S. Brown, (already alluded to,) will be chief engineer. It is noteworthy that the American great enterprise is by a private company; the Russian is built by Government.

The first charter for a railroad in this country was granted by New Jersey. The Legislature, at the session of 1814–15, chartered the New Jersey Railroad Company, to build a road four rods wide from the river Delaware, near Trenton, to the River Raritan, near New Brunswick. The country was not then prepared for the enterprise, and the work was abandoned. The honor of introducing railroads was reserved for Massachusetts, and the first road that was built on this continent, was the Quincy Railroad, from the quarry to Neponset river, which was first used in the year 1827.

At the close of the year 1848, there were 1,614 miles of railroad in operation in New York, and on the 1st of December, 1849, there were 2,133, showing an increase, in eleven months, of 510 miles. By the 1st of January, 1850, there were about 150 miles more in operation, which will make the aggregate length 2,283 miles, and the total increase 669 miles. In the State of New York there has been an increase of about 400 miles. In the Southern and Western States, a great many miles of railroad have been opened this year. The total number of miles of railroad put in operation in the United States, during the year 1849, was not much less than 2,000. At the close of the year 1848, it was estimated that there were 6,120 miles of railroad in the United States; to which add the 2,000 opened, and the aggregate at the close of 1849, would have been 8,120 miles.

New York and Erie Railroad.—The line is now open to Dunkirk. The whole cost of equipments, buildings, &c., is about twenty and a half millions of dollars, and the cost about $38,706 per mile —not counting the machinery and buildings. This is an enormous sum, but the expense of construction is very moderate, considering the difficulties of the work, and the manner in which it has been performed. The earnings for the year 1850 have been $1,600,300, or $5,000 per mile; in 1849 they were only $3,697 per mile. This is a great increase, but nothing to what may be expected now that the road is finished. This road runs through some of the grandest mountain scenery in our country. The bridges, cuttings, and gradings are works of great magnitude. The most able engineers and architects have been employed by the company. This road is of a wider track than the common roads in our country. It is now an unbroken line of wide track 543 miles long, and at the rate of 30 miles per hour, a traveller will be able to reach Erie from New York in 18 hours.

The State of Georgia has been much improved by the lines which traverse it. By the Central Railroad of 191 miles, and the Macon and Western of 101 miles, she has a direct communication with Atlanta, distant, in all, 292 miles, through the heart of the State, embracing its richest regions, which field is widened by the cross lines of the Southwestern and the Macon and Columbus roads, stretching to different points of the valley of the Chattahoochie and the borders of Alabama; and the intended extensions, northward from Atlanta, of the main central route to Nashville on the one side, and to Knoxville on the other, will open to her the vast and as yet undeveloped wealth of Tennessee.

In Indiana, 1,205 miles of railroad have been projected, and 212 have been completed.

The following is a summary of the principal lines of railroad in the United States:

Names.	States.	Places connected.	Length.
Bangor and Piscataquis	Maine	Bangor and Oldtown	12
Atlantic and St. Lawrence	Do.	Portland and Canada Line	156
Kennebec, Bath, and Portland	Do.	Portland and Augusta	60
Androscoggin and Kennebec	Do.	Augusta and Lewiston Falls	30
Portsmouth and Concord	New Hampshire	Portsmouth and Concord	40
Concord and Montreal	Do.	Concord and Montreal Railroad	69
Nashua and Concord	Do.	Nashua and Concord	35
Cheshire	Mass., N. H.	S. Ashburnham and Bellows Falls	60
Sullivan	Vermont	Bellows Falls and Hartford, Vt.	25
Connecticut and Passumsic	Do.	Hartford and Derby, Canada Line	114
Vermont Central	Do.	Hartford and Burlington	115
Rutland	Do.	Bellows Falls and Rutland	117
Fitchburg	Massachusetts	Boston and Fitchburg	50
Vermont and Massachusetts	Vermont, Mass.	Fitchburg and Brattleborough	70
Boston and Maine	Mass., N. H., M.	Boston and Portland	170
Eastern	Do. do. do.	Boston and Portland	105
Peterborough and Shirley	Mass., N. H.	Groton and Peterborough	3[illegible]
Fitchburg and Worcester	Massachusetts	Fitchburg and Worcester	1[illegible]
Lowell and Lawrence	Do.	Lowell and Lawrence	12½
Norfolk County	Do.	Boston and Prov. R. R. & Blackstone	25
Nashua and Lowell	Do.	Nashua and Lowell	14½
New Bedford and Taunton	Do.	New Bedford and Taunton	20
Old Colony	Do.	Boston and Plymouth	37½
Fall River	Do.	Boston and Fall River	5[illegible]
Boston, Providence, and Stonington	Mass., R. I., Ct.	Boston, Providence, and Stonington	8[illegible]
Boston, Worcester, and Western	Mass. and N. Y.	Boston and Albany	200
Providence and Worcester	Mass. and R. I.	Providence and Worcester	43
Connecticut River	Mass. and Vt.	Springfield and Brattleborough	5[illegible]
Worcester and Norwich	Mass. and Ct.	Worcester and Norwich	66
N. Haven, Hartford, and Springfield	Do. do.	New Haven, Hartford, & Springfield	57
Canal	Connecticut	New Haven and W. Springfield	58½
Naugatuc	Do.	Bridgeport and Winsted	59
New London and Willimantic	Ct. and Mass.	New London and Palmer, Mass.	6[illegible]
New Haven and New-York	Ct. and N. Y.	New Haven and New York	76
Housatonic	Ct. and Mass.	Bridgeport and West Stockbridge	[illegible]
Long Island	New-York	Brooklyn and Greenport	95
Hudson River	Do.	New-York and Albany	14[illegible]
Western	Do.	Albany and Buffalo	327
New-York and Erie	Do.	Piermont and Dunkirk	45[illegible]
Buffalo and Niagara	Do.	Buffalo and Niagara Falls	22
Oswego and Syracuse	Do.	Oswego and Syracuse	41
Saratoga and Schenectady	Do.	Saratoga and Schenectady	22
Cayuga and Susquehanna	Do.	Ithaca and Owego	2[illegible]
New Jersey, Trenton, and Philadel.	N. J. and Pa.	Jersey City and Philadelphia	9[illegible]
Camden and South Amboy	Do.	Camden and South Amboy	61
Philadelphia and Reading	Pennsylvania	Philadelphia and Reading	92
Philadelphia and Columbia	Do.	Philadelphia and Columbia	82
Harrisburg and Chambersburg	Do.	Harrisburg and Chambersburg	56
Philadelphia and Baltimore	Pa., Del., Md.	Philadelphia and Baltimore	97
Baltimore and Susquehannah	Md. and Penn.	Baltimore and Columbia	71
Baltimore and Ohio	Md. and Va.	Baltimore and Cumberland	179
Baltimore and Washington	Md. and D. of C.	Baltimore and Washington	40
Richmond and Potomac	Virginia	Acquia Creek and Richmond	76
Richmond and Petersburg	Do.	Richmond and Petersburg	22
Petersburg	Va. and N. Car.	Petersburg and Weldon	63
Wilmington and Weldon	N. Carolina	Wilmington and Weldon	161
South Carolina	S. Carolina	Charleston and Hamburg	136
Georgia	Georgia	Augusta and Atlanta	171
Western and Atlantic	Do.	Atlanta and Dalton	100
Central	Do.	Savannah and Macon	191
Montgomery and West Point	Ala. and Geo.	Montgomery and West Point	67
Tuscumbia and Decatur	Do. do.	Tuscumbia and Decatur	44
Vicksburg	Mississippi	Vicksburg and Clinton	46
Lexington and Ohio	Kentucky	Lexington and Frankfort	28
Mad River and Erie	Ohio	Sandusky and Springfield	34
Little Miami	Do.	Springfield and Cincinnati	81

Names.	States.	Places connected.	Length.
Mansfield and Sandusky............	Do............	Mansfield and Sandusky............	56
Madison and Indianapolis	Indiana	Madison and Indianapolis	86
Detroit and Pontiac	Michigan.......	Detroit and Pontiac...............	25
Michigan Southern................	Do.	Monroe and Hillsdale	70
Michigan Central	Do.	Detroit and Kalamazoo.............	146
Erie and Kalamazoo...............	Mich. and Ohio	Toledo and Adrian................	33
Hudson River	New-York	New-York and Albany, as far as Poughkepsie completed	
Rutland and Burlington	Vermont	Rutland and Burlington	120

It is calculated that at the end of 1851, there will be 10,600 miles of railroads in operation in our country; and with those which have already been contracted for, there will be 2,000 miles more constructed in 1852. No country in the world can equal ours for the number of railroads.

Besides the lines in this country, other lines are in contemplation; such as the Canadian line connecting Halifax with Montreal and the Isthmus.

The Panama Railroad. The Panama Railroad progresses very slowly, but it is said that it will be finished in three years. There are but three stations formed at present. There will be one more, making four from Navy Bay to Gorgona, as follows:—1st, Navy Bay, the commencement; 2d, Gatun, about 7 miles from Navy Bay; 3d, Bohia Soldado, (soldier's camp); 4th, Juan Grand, (Great John.) The distance from Navy Bay to Gorgona, by railroad, is 28 miles; the Chagres River will be crossed by a bridge, 1¼ miles this side of Gorgona. Nothing has been done or commenced on the other side of Gorgona, nor will there be until this is finished. There will be some stupendous work between Gorgona and Panama—a tunnel is to be made of about 3,000 feet.

The air line distance from Chagres to Panama, is 30¾ miles. The highest point of land on the line of road between Gorgona and Panama is 320 feet above the Pacific. The Pacific is 12 feet 6-100 higher than the Atlantic. The greatest rise of water known at Panama, 22 feet; the least, 10. There are swamps between Navy Bay and Gatun 2¼ feet lower than the Atlantic. The grade of the road from Navy Bay to Gorgona, 26 feet to the mile: Gorgona to Panama, by mule path, 22 miles; Cruces to Panama, by mule path, 17 miles; Isthmus of Tehuantepec, air line distance between the Atlantic and the Pacific, 132 miles; Nicaragua, air line distance between the Atlantic and the Pacific, 90 miles.

Railway, Pneumatic or Atmospheric. The name given to a system of locomotion on railways by means of the pressure of the atmosphere. A simple and ingenious apparatus for this purpose was invented a few years ago, and is now being exhibited on the West London Railway at Wormwood Scrubs.

The Croydon Railway, in England, was worked on the atmospheric principle for a few years. The Kingston and Dalkey Railway, Ireland (2¼ miles), was also laid down in single line on the atmospheric principle. The tube in which the air to be removed was contained was placed in connection with a steam pump, which produced a vacuum, and dragged the car on which was attached to the movable piston in the tube. The cars were drawn up by the vacuum to the Dalkey terminus, and returned to Kingston by gravity, the inclination of the line being very great. The expense of working this line exceeded its income by £700 per year, and it consequently was given up. So was the Croydon line, from a similar reason, though the rapidity of travel is probably greater than can be attained by a locomotive: on this latter line it reached the rate of 75 miles per hour, for the distance of ¼ of a mile.

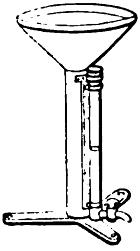
The defects of this mode of working the atmospheric principle has led to various novel recommendations, none of which have been put in force.

RAIN-GAUGE, also called **OMBROMETER**, **UDOMETER**, and **PLUVIAMETER**. An instrument for measuring or *gauging* the quantity of rain which falls at a given place.

"The *rain-gauge* may be of very simple construction. A cubical box of strong tin or zinc, exactly 10 inches by the side, open above, receives at an inch below its edge a funnel, sloping to a small hole in the centre. On one of the lateral edges of the box, close to the top of the cavity, is soldered a short pipe, in which a cork is fitted. The whole should be well painted. The water which enters this gauge is poured through the short tube into a cylindrical glass vessel, graduated to cubic inches and fifths of cubic inches. Hence, one inch depth of rain in the gauge will be measured by 100 inches of the graduated vessel, and 1-100th inch of rain may be very easily read off.

"It is very much to be desired that, being of such easy construction, more than one of these gauges should be erected; or at least one placed with its edge nearly level with the ground, and another upon the top of the highest building, rock, or tree in the immediate vicinity of the place of observation, the height of which must be carefully determined, it having been satisfactorily ascertained that the height of the gauge above the ground is a very material element of the quantity of rain which enters it. The quantity of water should be daily measured and registered at 9 A. M."

A convenient form of the instrument is represented in the annexed figure, where the rain which enters the funnel is collected in a cylindrical vessel of copper, connected with which at the lower part is a glass tube with an attached scale. The water stands at the same height in the cylinder and glass tube, and being visible in the latter, the height is read immediately on the scale; and the cylinder and tube being constructed so that the sum of the areas of their sections is a given part, for instance a tenth of the area of the funnel at its orifice, each inch of water in the tube is equivalent to the tenth of an inch of water entering the mouth of the funnel. A stop-cock is added, by which the water is drawn off when the observation is made.



RASP, MECHANICAL. Is the name given by the French to an important machine much used for mashing beet-root.

RATAFIA. A liqueur prepared from various kinds of fruit, and named after the fruit which is employed. Ratafia de cassio has cherries; ratafia de curacoa has the peels of Portugal oranges; ratafia d'angelique has anglician seeds; ratafia d'anis has aniseed, and so on. The French liquerists are the most skilled in this as in most branches of delicate distillation and making of essences.

RATCHET, in clock and watch work, is the name given to an arm or piece of mechanism, one extremity of which abuts against the teeth of a *ratchet wheel*, and the other extremity is either freely jointed to a reciprocating driver for the purpose of communicating a continuous motion to the wheel, or is attached to a fixed centre to insure the wheel against reverse motion. In the former case it is also called a *click* or *paul*, in the latter, a *detent*.

RATCHET WHEEL. A wheel having teeth formed like those of a saw, against which the ratchet abuts. *See* RATCHET.

RAZOR. *See* CUTLERY.

REACTION. A termed used in mechanics to denote the reciprocality of force exerted upon two bodies which act mutually on each other; or the general fact, collected from observation, that any two bodies repelling or attracting each other are made to recede or approach with equal momenta. Newton's third law of motion is, that "reaction is always contrary and equal to action, or that the mutual actions of two bodies are always equal, exerted in opposite directions." In the mathematical consideration of mechanics, this principle must be assumed as a necessary axiom or law; and, in fact, as is remarked by Dr. Young, there would be something peculiar, and almost inconceivable, in a force which could affect unequally the similar particles of matter; or in the particles themselves, if they could be supposed of such different degrees of mobility as to be equally movable with respect to one force, and unequally with respect to another. The principle may, therefore, as justly be termed a necessary law as an experimental fact.

REALGAR. *See* ARSENIC.

RECTIFICATION is the final purification of liquors, generally alcohol, by distillation. It is not often carried on under the same roof with the distillation.

Rectifiers receive malt spirits from distillers from proof to 25 per cent. Their business is to re-distil once for rectification. Then to distil again with various vegetable and chemical substances so as to produce flavors called gin, hollands, brandy, peppermint, and other cordials. For gin, Italian and German juniper-berries, and coriander-seeds. Hollands are made from rye-spirit, flavored with juniper and other ingredients. *See* BRANDY, &c. In rectifying spirits for gin, proof is reduced to 17 and 22 per cent. under proof, and at that strength sold to the dealers.

In the trade of spirits, there is the distiller, who makes the spirit from the fermented grain and wash; the rectifier, who concentrates, compounds, and flavors it; the merchant-dealer; and the retailer, in the gin-shop and public-house.

To determine the probable produce of wines, &c., intended for distillation, a small alembic has been invented at Paris, adapted to heating with spirits of wine, and a glass vessel used as a recipient, so that a single glass of wine may be distilled. It was adopted as a toy, and became the means by which families made all kinds of flavored waters. The leaves of oranges, roses, &c., &c., were laid on gratings above the water, and the vapor rising through them received their odor and flavor. The whole weighs but 5 or 6 lbs. and is in a box but 16 inches long and 3 or 4 square.

The ordinary method of conducting the process, consists in placing the liquid to be distilled in a vessel called a still made of copper, having a moveable head, with a swan like neck, which is so formed as to fit a coiled tube packed away in a tub of water, constantly kept cold, and which is termed a refrigeratory or worm tub. The charge of a *wash* still is from 16 to 20,000 gallons, and the *low-wines* still is the produce of the wash still, and from this are produced *spirits* and *feints* in separate vessels. The feints are turned into the next wash still. The spirits are then sold to rectifiers, who re-distil, flavor, and prepare for consumption.

A liquid obtained by distillation is sometimes not perfectly pure, or it is dilute, from the intermixture of water, that has been elevated in vapor along with it. By repeating the distillation of it a second or a third time, it is rendered more pure and strong. This latter process is named *rectification*, or sometimes *concentration*.

RED-LEAD. *See* LEAD and MINIUM.

REED is the well-known implement of the weaver, made of parallel slips of metal or reeds, called dents. A thorough knowledge of the adaptation of yarn of a proper degree of fineness to any given measure of reed, constitutes one of the principal objects of the manufacturer of cloths; as upon this depends entirely the appearance, and in a great degree the durability, of the cloth when finished. The art of performing this properly is known by the names of *examining*, *setting*, or *sleying*, which are used indiscriminately, and mean exactly the same thing. The reed consists of two parallel pieces of wood, set a few inches apart, and they are of any given length, as a yard, a yard and a quarter, &c. The division of the yard being into halves, quarters, eighths, and sixteenths, the breadth of a web is generally expressed by a vulgar fraction, as 1-4th, 4-4ths, 5-4ths, 6-4ths; and the subdivisions by the eighths or sixteenths, or *nails*, as they are usually called, as 7-8ths, 9-8ths, 11-8ths, &c., or 13-16ths, 15-16ths, 19-16ths, &c. In Scotland, the splits of cane which pass between the longitudinal pieces or ribs of the reed, are expressed by hundreds, porters, and splits, the porter is 20 splits, or 1-5th of a hundred.

The number of threads in the warp of a web is generally ascertained with considerable precision by means of a small magnifying glass, fitted into a socket of brass, under which is drilled a small round hole in the bottom plate of the standard. The number of threads visible in this perforation, ascertains the number of threads in the standard measure of the reed. Those used in Scotland have sometimes four perforations, over any one of which the glass may be shifted. The first perforation is 1-4th of an inch in diameter, and is therefore well adapted to the Stockport mode of counting; that is to say, for ascertaining the number of ends or threads per inch; the second is adapted for the Holland reed, being 1-200th part of 40 inches; the third is 1-700th part of 37 inches, and is adapted for the now almost universal construction of Scotch reeds; and the fourth, being 1-200th of 34 inches, is intended for the French cambrics. Every thread appearing in these respective measures, of course represents 200 threads, or 100 splits, in the standard breadth; and thus the quality of the fabric may be ascertained with considerable precision, even after the cloth has undergone repeated wettings, either at the bleaching-ground or dye-work. By counting the other way, the proportion which the woof bears to the warp is also known, and this forms the chief use of the glass to the manufacturer and operative weaver, both of whom are previously acquainted with the exact measure of the reed.

REFINING OF GOLD AND SILVER; called also *Parting*. For several uses in the arts, these precious metals are required in an absolutely pure state, in which alone they possess their malleability and peculiar properties in the most eminent degree. Thus, for example, neither gold nor silver leaf can be made of the requisite fineness, if the metals contain the smallest portion of copper alloy. Till within these ten or twelve years, the parting of silver from gold was effected everywhere by nitric acid.

2. *On parting by the nitric acid.* The principle on which this process is founded, is the fact of silver being soluble in nitric acid, while gold is insoluble in that menstruum. If the proportion of gold to that of silver be greater than one to two, then the particles of the former metal so protect or envelope those of the latter, that the nitric acid, even at a boiling heat, remains quite inactive on the alloy. It is indispensable, therefore, that the weight of the silver be at least double that of the gold. 100 pounds of silver take 38 pounds of nitric acid, of specific gravity 1·320, for oxidizement, and 111 for solution of the oxide; being together 149; but the refiner often consumes, in acid of the above strength, more than double the weight of silver, which shows great waste, owing to the imperfect means of condensation employed for recovering the vapors of the boiling and very volatile acid.

100 pounds of copper require 130 pounds of the above acid for oxidizement; and 390 for solution of the oxide; being 520 pounds in whole, of which less than ¼th part could be recovered by the above apparatus. It is therefore manifest that it is desirable to employ silver pretty well freed from copper by a previous process; and always, if practicable, a silver containing some gold.

In parting by nitric acid, the gold generally retains a little silver; as is proved by the cloud of chloride of silver which it affords, at the end of some hours, when dissolved in aqua regia. And on the other hand, the silver retains a little gold. These facts induced M. Dizé, when he was inspector of the French mint, to adopt some other process, which would give more accurate analytical results; and after numerous experiments, he ascertained that sulphuric acid presented great advantages in this point of view, since with it he succeeded in detecting, in silver, quantites of gold which had eluded the other plan of parting. The suggestion of M. Dizé has been since universally adopted in France. M. Costell, about nine or ten years ago, erected in Pomeroy street, Old Kent road, a laboratory upon the French plan, for parting by sulphuric acid; but he was not successful in his enterprise; and since he relinquished the business, Mr. Matheson introduced the same system into our Royal Mint, under the management of M. Costell's French operatives. In the Parisian refineries, gold, to the amount of one thousandth part of the weight, has been extracted from all the silver which had been previously parted by the nitric acid process; being 3,500 francs in value upon every thousand killogrammes of silver.

The most suitable alloy for refining gold, by the sulphuric acid process, is the compound of gold, silver, and copper, having a standard quality, by the cupel, of from 900 to 950 milliemes, and containing one fifth of its weight of gold. The best proportions of the three metals are the following:—silver, 725; gold, 200; copper, 75;=1000. It has been found that alloys which contain more copper afford solutions that hold some anhydrous sulphate of that metal in solution, which prevents the gold from being readily separated; and that alloys containing more gold are not acted on easily by the sulphuric acid. The refiner ought, therefore, when at all convenient, to reduce the alloys that he has to treat to the above stated proportions. He may effect this purpose either by fusing the coarser alloys with nitre in a crucible, or by adding finer alloys, or even fine silver, or finally, by subjecting the coarser alloys to a previous cupellation with lead on the great scale. As to gold or silver bullion, which contains lead and other easily oxidizable metals besides copper, the refiner ought always to avoid treating them by sulphuric acid; and should separate, first of all, these foreign metals by the agency of nitre, if they exist in minute quantity; but if in larger, he should have recourse to the cupel. Great advantage will therefore be derived from the judicious preparation of the alloy to be refined.

For an alloy of the above description, the principal Parisian refiners are in the habit of employing thrice its weight of sulphuric acid, in order to obtain a clear solution of sulphate of silver, which does not too suddenly concrete on cooling, so as to obstruct its discharge from the alembic by decantation. A small increase in the quantity of copper calls for a considerable increase in the quantity of acid.

Generally speaking, one half of the sulphuric acid strictly required for converting the silver and copper into sulphates, is decomposed into sulphurous acid, which is lost to the manufacturer, unless he has recourse to the agency of nitrous acid.

The Parisian refiners restore to the owners the whole of the gold and silver contained in the ingots, reserving to themselves the copper which formed the alloy, and charging only the sum of 5¼ francs per killogramme (2·68 lbs. troy) for the expense of the parting of the metals.

If they are employed to refine an ingot of silver containing less than one tenth of gold, they retain for themselves a two thousandth part of the gold, and all the copper, existing in the alloy; return all the rest of the gold, with the whole of the silver, in the ingot; and give, besides, to the owners a *premium* or *bonus*, which amounted lately to ¾ths of a franc on the kilogramme of metal. Should the owner desire to have the whole of the gold and silver contained in his ingot, the refiner then demands from him 2 francs and 68 centimes per kilogramme, retaining the copper of the alloy. As to silver ingots of low standard, the perfection of the refining process is such, that the mere copper contained in them pays all the costs; for in this case, the refiner restores to the proprietor of the ingot as much fine silver as the assay indicated to exist in the ingot, contenting himself with the copper of the alloy.

REFLECTING CIRCLE. An astronomical instrument for the measurement of angles by reflection. *See* SEXTANT. The term is also applied to a surveying instrument, invented by Sir Howard Douglas, which combines the advantages of the Hadley's quadrant and the protractor. The object of it is to protract, or lay down on the plan, the angles measured with the instrument from the instrument itself, without any intermediate step, or even a register of their values. The advantage of such an instrument must be obvious in military surveys, where expedition is important, while accuracy is thereby far more efficiently insured than by the old and more tedious process. It is also advantageously used in forming general sketches of a country.

To improve it, J. C. Dennis suggests:—Instead of attaching the circle, technically called an arc, to the parts which support it, let the whole be cast in one piece, then placed, polished, or divided, to suit the purposes of modern astronomy. This intrument is capable of distinguishing to the 5940th part of an inch.

REFLEXION, in mechanics, denotes the rebound or regressive motion of a body from the surface of another body against which it impinges. In natural philosophy, the term is applied to the analogous motions of light, heat, and sound, when turned from their course by an opposing surface. The laws of the reflexion of light form the branch of science called *catoptrics;* those of the reflexion of sound are sometimes called *cataphonics.*

The simplest view which can be taken of the mechanical action whereby reflexion is produced, is to assimilate it to that which takes place when an elastic body impinges on another body which it cannot move out of its place. If light, heat, and sound are propagated by the pulses of an elastic medium, the same theory will apply to them; and it is to be remarked, that in all cases of reflexion the change of motion which takes place follows precisely the same laws as that which is produced by the impact of two elastic bodies.

REGULATOR. In machinery, a general name for any contrivance of which the object is to produce the uniform movement of machines. The regulators most commonly applied are the *fly* and the *governor*, for which see the respective terms.

The regulator of a watch is the spiral spring attached to the balance. This ingenious contrivance, the invention of Hooke, has contributed as much to the improvement of watches as the pendulum to the improvement of clocks.

The present Astronomer Royal of England has investigated the mathematical problem of the motion of the regulator applied to the clock-work by which motion is given to large equatorial telescopes. For this purpose, absolute uniformity of motion is of very great importance. The construction, usually adopted, in this country at least, depends on the same principle as that of the governor of the steam-engine. Two balls, suspended from the upper part of a vertical axis by rods of a certain length, are made to expand by the rotatory velocity of the axis; and when the expansion reaches a certain limit, a lever is pressed against some revolving part, whereby a friction is produced which immediately checks the velocity. Now the uniformity of the rotatory motion of the spindle depends upon the assumption, that if upon the whole the retarding forces are equal to the accelerating forces, the balls will move in a circle, and in no other curve. But this assumption is incorrect; for the balls may move in a curve differing insensibly from an ellipse; and, in some instances, Mr. Airy observed the balls to revolve in an ellipse of considerable eccentricity. When this takes place, the rotatory motion of the spindle becomes exceedingly variable. This injurious effect may be partly counteracted by constructing the apparatus so that the revolutions shall be either very slow or very quick; the former method has the effect of giving greater smoothness of motion, but the second insures more completely that the object observed shall remain steady in the field of the telescope.

RELIEF. In architecture, the projection of a figure or ornament from the ground or plane on which it is sculptured. In sculpture, when the whole of the figure stands out, the work is denominated *alto-relievo;* when only half out, *demi-relievo;* and when its projection is very small, it is called *basso-relievo.*

Relief, *Relievo.* In sculpture, that species of sculpture in which the figures are engaged on or rise from a ground. There are three sorts of *relievo—basso relievo*, in which the figures or other objects have but small projection from the ground on which they are sculptured; *mezzo-relievo*, in which the figures stand out about half their natural proportions, the other half appearing immersed in the ground; and, lastly, *alto-relievo*, in which the figures stand completely out from the ground, being attached to it only in a few places, and in others worked entirely round like single statues; such are the metopæ of the Elgin marbles in the British Museum, which marbles also, in the Panathenaic procession, exhibit some exquisite examples of basso-relievo.

REPEATING CIRCLE. In order to diminish the effect of errors of graduation, and to obtain very accurate measurements by means of comparatively small, and, therefore, portable instruments, a method of observing was invented, or rather brought into use, by Borda, which is now extensively employed, especially in geodetical operations. The method, which consists in moving the telescope successively over portions of the graduated limb corresponding to the angle to be measured, and reading only the multiple arc, may be advantageously applied to circular instruments destined for very different purposes: as, for example, to an instrument for the measurement of the zenith distances of stars or terrestrial objects, or the distance of two trigonometrical stations, in which case it is simply called called *repeating circle;* to a reflecting circle used for observations at sea, when it becomes a *repeating reflecting circle;* or to a theodolite, when it becomes a *repeating theodolite.*

When the repeating circle is used for measuring zenith distances, it is constructed so as to be capable of being turned round on a vertical pivot, the direction of which passes through its centre, and to which its plane is parallel, and also of turning in its own plane about a horizontal axis. The instrument being placed in the same vertical plane with the star, the telescope is directed to the star and the bisection made; the telescope, which carries the verniers with it, is then firmly clamped to the circle, and the circle turned round 180° in azimuth about the vertical pivot. If the circle be now kept fast, the telescope unclamped and carried round till the star is again bisected, it is plain that the arc of the limb passed over by the verniers in consequence of this motion of the telescope will be double the zenith distance of the star. The same process is repeated as often as may be thought necessary. For the purpose of geodetical measurements the circle is usually furnished with two telescopes, one on the face, and the other on the back; and so placed that the optical axes of both are exactly in the plane of the circle. The circles used by Mechain and Delambre in the operations connected with the measurement of the French arc of meridian, were about 4-10ths of a metre (nearly 16 inches) in diameter, and were divided into arcs equivalent to about 32 sexagesimal seconds, which were subdivided into tenths by the verniers.

The merit of first applying the ingenious principle of repetition to angular measurements, belongs to Tobias Mayer, but it was Borda, as above stated, who first brought the instrument into general use. For a description of the repeating circle, its adjustment, and the method of using it, *see* Biot. Astronomie Physique, tome i.; Delambre Astronomie on Base Metrique, tome i., Puissant traité de Geodésie; Roper's Practice of Navigation. The comparative advantages and defects of the instrument are very clearly stated in a paper by Troughton, in the 1st volume of the Memoirs of the Royal Astronomical Society.

RESINS are proximate principles found in most vegetables, and in almost every part of them; but the only resins which merit a particular description, are those which occur naturally in such quantities as to be easily collected or extracted. They are obtained chiefly in two ways, either by spontaneous exudation from the plants, or by extraction by heat and alcohol. In the first case, the discharge of resin in the liquid state is sometimes promoted by artificial incisions made in summer through the bark into the wood of the tree.

Resins possess the following general properties:—They are soluble in alcohol, insoluble in water, and melt by the application of heat, but do not volatilize without partial decomposition. They have rarely a crystalline structure, but, like gums, they have no particular form. They ignite readily, burn with a bright light, and give much smoke. They are quite insoluble in water, but dissolve readily in cold and hot alcohol, from which they are precipitated by water. Resins dissolve in ether and volatile oils, and by heat combine with fat oils. They mix with sulphur and phosphorus. Carburet of sulphur dissolves them, chlorine bleaches them, and nitric acid converts them into artificial tan. Every natural resin is a compound of two or three pure resins, as is the case with oils. Some are soluble in hot or cold alcohol—ether, naptha, and turpentine. Resins which contain essential oil are called *balsams*; a few contain benzoin acids. The solid resins are amber, animé, benzoin, colophony copal, copal, danunara, dragon's blood, elemi, gniac, lac, jalap resin, ladanum, mastic, sandarach, storax, tacamahac.

An ingenious memoir upon the resins of dammar, copal, and animé, has lately been published by M. Guibourt, an eminent French *pharmacien*, from which the following extract may be found interesting.

The *hard* copal of India and Africa, especially Madagascar, is the product of the *hymenæa verrucosa*; it is transparent and vitreous within, whatever may be its appearance outside; nearly colorless, or of a tawny yellow; without taste or smell in the cold, and almost as hard as amber, which it much resembles, but from which it may be distinguished, 1st, by its smelting and kindling at a candle-flame, and running down in drops, while amber burns and swells up without flowing; 2dly, this hard copal or animé, when blown out and still hot, exhales a smell like balsam copaiva or capivi; while amber exhales an unpleasant bituminous odor; 3dly, when moistened by alcohol of 85 per cent., copal becomes sticky, and shows after drying a glazed opaque surface, while amber is not affected by alcohol; 4thly, the copal affords no succinic acid, as amber does, on distillation.

When the pulverized copal is digested in cold alcohol of 0·830, it leaves a considerable residuum, at first pulverulent, but which swells afterward, and forms a slightly coherent mass. When this powder is treated with boiling alcohol, it assumes the consistence of a thick gluten, like crumbs of bread, but which does not stick to the fingers.

RESISTANCE, in mechanics, denotes generally a force acting in opposition to another force, so as destroy it or diminish its effect. Resistance is sometimes considered as of two kinds, active and passive; the active resistance being that which corresponds to the useful effect produced by a machine, and the passive that which belongs to the inertia of the machine. Thus, in raising water from a well, the active resistance to the force employed is measured by the quantity of water which is raised; and the passive resistance by the force required to overcome the weight of the bucket and the rope, the friction of the pulley on its axle, &c.

RESISTANCE OF FLUIDS. In hydrodynamics, the force with which a solid body moving through a fluid is resisted or retarded. Of all the different kinds of resistance which manifest themselves among bodies, there is none of greater importance than this, on account of its application to the theory of naval architecture.

Sir Isaac Newton was the first who gave a general theory of the motions and actions of fluids. The Newtonian theory of the resistance of fluids, which is given in the second book of the *Principia*, is founded on the assumption of the perfect intermobility of the particles of the fluid, and the equal propagation of pressure in all directions. These are, indeed, the characteristic properties of fluidity; nevertheless, the results of the mathematical theory differ so widely in many cases from actual experiment, that some philosophers have called in question the accuracy of the principles from which they are derived. The theory, however, notwithstanding its defects, furnishes some propositions of great practical use, and, indeed, forms the groundwork of all our knowledge on the subject.

It is evident that a solid body, in moving through a fluid, must communicate a motion to the fluid particles with which it successively comes in contact. Now, the quantity of motion communicated to the fluid is necessarily equal to that which is lost by the solid, and may therefore be taken as the measure of the resistance. To determine this quantity of motion, let us conceive a cylindrical or prismatic body, terminated by a plane perpendicular to its axis, to be propelled through a non-elastic fluid in the direction of its axis, so that the particles of the fluid strike against the plane perpendicularly.

Numerous experiments have been made for the purpose of ascertaining how far the theory of the resistance of fluids agrees with the actual facts, or for forming an empirical theory for the guidance of the engineer. Of the details of these experiments our limits will not permit us to give an account. The general results of the experiments may be stated as follows:—

I. The force of resistance on bodies moving in fluids is proportional to the square of the velocity, at least within the limits of 2 to 10 feet per second. This is in accordance with the theory.

II. The direct resistance on bodies moving with the same velocities is nearly in the ratio of the surfaces.

III. The resistances on surfaces moving obliquely do not by any means vary in the ratio of the squares of the sines of the angles of incidence, especially when the incidence is very oblique; and for such motions the theory must be entirely abandoned.

The above results are, however, considerably modified by various circumstances, of which the principal are the following:—

1. The form of the body. The Newtonian theory takes account only of the anterior surface of the body; but it was clearly established by the experiments of Du Buat that the form of the hinder part is not less efficacious in modifying the resistance. A prismatic body, having its prow and poop equal and parallel surfaces, being plunged horizontally into a stream, will require, in order to keep it immovable, a force in the direction of its axis equal to the difference of the real pressure exerted on its prow and poop. If the fluid is at rest, this difference will be nothing, because the opposite dead pressures are equal; but in a stream there is superadded to the dead pressure on the prow the active pressure arising from the deflection of the filaments of the fluid, which being turned aside and rendered divergent by the obstruction of the anterior surface, a part of the pressure of the circumambient fluid is employed in turning them into the trough behind the body, and consequently there is less pressure on the posterior surface than if the body were at rest in stagnant water, so that the body is impelled backwards. This force is called by Du Buat the *non pressure*; by Beaufoy the *minus pressure*. Now, the whole impulse to be withstood if the body is in a stream, or the resistance to be overcome if it moves in stagnant water, is the sum of the active pressure on the fore part and the non-pressure on the hinder part; and this does not depend solely on the form of the prow and poop, but also, and perhaps chiefly, on the length of the body. The non-pressure on a cube was found by experiment to be reduced to a fourth part, by making the length of the body triple of the breadth. The mere lengthening of a ship, without changing the form of the prow or poop, increases the speed.

2. Another circumstance which modifies the general results is the velocity of the body. It was ascertained, by Mr. Russell's experiments on canal boats, that the resistance does not follow the ratio of the squares of the velocities, excepting when the velocity is small and the depth considerable; but that the increments of the resistance are greater than those due to the squares of the velocities as the velocity approaches to a certain limit depending on the depth of the fluid; and that immediately after passing this limit the resistance suffers a sudden diminution, and becomes much less than that due to the square of the velocity. In a canal about five and a half feet deep, this limit (which is the velocity of the wave generated by the motion of the body) was found to be from 11 to 12 feet per second, or about eight miles per hour.

3. A third cause which modifies the theory is the adhesion of the molecules of the fluid, which is most sensible when the motion is slow and the body small and very long. In such cases, it becomes necessary to add a term depending on the first power of the velocity.

4. The resistance is also influenced by the depth of the body under the surface of the water. When the body is near the surface the resistance is greater than when it is at the depth of six feet. When a body floats, the fluid is heaped up, as it were, before the anterior surface, by which the resistance is increased.

5. In elastic fluids, as the density increases with the pressure, the density of the fluid before the anterior surface increases with the velocity, and the increments of the resistance are greater than

in the ratio of the square of the velocity. In this case, also, we may conceive a velocity so great that the pressure on the posterior surface becomes negative, as in the case of a cannon ball projected with a velocity greater than that with which air rushes into a vacuum. When this takes place the fluid is not even in contact with the posterior surfaces of the ball, and the character of the resistance is wholly changed.

6. When a body moves in a fluid a portion of the fluid adheres to the body, and accompanies it in its motion; whereby the form of the moving body is altered, and the resistance increased. The quantity of fluid thus dragged along is independent of the velocity, and was estimated by Du Buat, from experiments made on spheres vibrating in water, to increase the quantity of displaced fluid in the ratio of 1 to 1·6. His experiments on prisms also showed that the quantity of dragged fluid was proportional to the bulk of the moving body. Mr. Baily gives, as the mean results of his experiments on pendulums swinging in air, the ratio 1 to 1·846 as the increase of the displaced fluid from this cause; and remarks that the quantity appeared to depend on the form as well as magnitude of the moving body, but not on its weight or specific gravity. This circumstance, which considerably modifies the resistance, though made known by Du Buat in 1786, was overlooked by other experimenters, until re-discovered by Bessel in 1826, when engaged on experiments to determine the length of the seconds' pendulum.

RESPIRATOR. A medium through which the air is carried before it enters the mouth and lungs. There are various forms of these instruments.

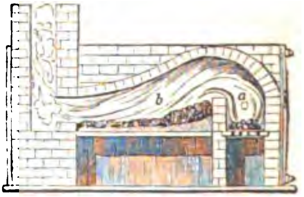
A Mr. A. S. Lyman, inventor of the Safety Steam and Water Gauge, which bears his name, has invented a beautiful apparatus, for inhaling medicated vapors by sick persons, and also to purify the atmosphere, which may be inhaled by any person. The latter quality of this neat apparatus will enable a person to go into, or labor in a deleterious atmosphere, without danger. A small cap-shaped reservoir of light material is fastened on the head with a neat tube secured to it, in such a manner that the wearer only inhales through it. This tube communicates with the atmosphere and with the small cap reservoir, which contains some purifying or disinfecting substance, such as moist lime, or fine charcoal, which absorbs impurities from the atmosphere, and allows the pure air only to be taken in by the lungs.

RETINASPHALTUM or RETINITE. A substance discovered by Mr. Hatchett, associated with Bovey coal, and which has since been found in other coal strata. When digested in alcohol it yields a portion of resin, and asphaltum remains; it appears, therefore, to be a substance intermediate between resin and bitumen, and renders it probable that bitumens are of resinous origin.

RETORT. A glass, metal, or earthen vessel, used in the distillation of chemical substances. Retorts of clay are now extensively used in gas-making.

REVERSING MOTION, is a very important principle in mechanics, and, in a general way, says Gregory, is effected "by making two equal pinions on one and the same axis, turn alternately into the teeth of those parts of a larger wheel which are nearly diametrically opposite; or, by means of an additional wheel, which may be thrown in or out of gear alternately."

REVERBERATING FURNACE, is that in which the roasting of metals and the puddling of iron is chiefly conducted. Its particular form varies, but the general principle of its construction is to have the roof or vault of the furnace so arched as to throw down or reverberate the flame and heated air upon the melted mass below. The cut illustrates the usual form of this kind of furnace.



RHODIUM, is a metal discovered by Dr. Wollaston in 1803, in the ore of platinum. It is contained to the amount of three per cent. in the platinum ore of Antioquia in Colombia, near Barbacoas; it occurs in the Ural ore, and, alloyed with gold, in Mexico. The palladium having been precipitated from the muriatic solution of the platinum ore previously saturated with soda, by the cyanide of mercury, muriatic acid is to be poured into the residuary liquid, and the mixture is to be evaporated to dryness, to expel the hydrocyanic acid, and convert the metallic salts into chlorides. The dry mass is to be reduced to a very fine powder, and washed with alcohol of specific gravity 0·837. This solvent takes possession of the double chlorides which the sodium forms with the platinum, iridium, copper, and mercury, and does not dissolve the double chloride of rhodium and sodium, but leaves it in the form of a powder, of a fine dark-red color. This salt being washed with alcohol, and then exposed to a very strong heat, affords the rhodium. But a better mode of reducing the metal upon the small scale, consists in heating the double chloride gently in a glass tube, while a stream of hydrogen passes over it, and then to wash away the chloride of sodium with water.

Rhodium resembles platinum in appearance. Any heat which can be produced in a chemical furnace is incapable of fusing it; and the only way of giving it cohesive solidity, is to calcine the sulphuret or arseniuret of rhodium in an open vessel at a white heat, till all the sulphur or arsenic be expelled. A button may thus be obtained, somewhat spongy, having the color and lustre of silver. According to Wollaston, the specific gravity of rhodium is 11. It is insoluble by itself in any acid; but when an alloy of it with certain metals, as platinum, copper, bismuth or lead, is treated with aqua regia, the rhodium dissolves along with the other metals; but when alloyed with gold or silver it will not dissolve along with them. It may, however, be rendered very soluble by mixing it in the state of a fine powder with chloride of potassium or sodium, and heating the mixture to a dull-red heat, in a stream of chlorine gas. It thus forms a triple salt, very soluble in water. The solutions of rhodium are of a beautiful rose color, whence its name. In the dry way, it dissolves by heat in bisulphate of potassa: and disengages sulphurous acid gas in the act of solution. There are two oxides of rhodium. Rhodium combines with almost all the metals; and, in small quantity, melted with steel, it has been supposed to improve the hardness, closeness, and toughness of this metal. Its chief use at present is for making the inalterable nibs of the so-named rhodium pens.

RHUBARB. The root of the *Rheum palmatum*, and perhaps some other species, cultivated in China for the supply of the drug market. The varieties of rhubarb known in commerce under the names of Russian, Turkey, and Indian rhubarb, are all derived from one source; but the select pieces are sold under the name of Russian and Turkey rhubarb, and those of somewhat inferior quality as East Indian. To judge of the quality of rhubarb, it should be cut or broken; when good it is of a mottled reddish or brownish red color; that which is very pale or very dark colored, and either so soft as to be spongy, or hard and stony in texture, is bad. Rhubarb is a valuable article of the materia medica, being an aperient, and at the same time a tonic and astringent.

There is a coloring matter (*erythrose*) obtainable from the rhubarb root, by digesting it in strong nitric acid, and removing the insoluble yellow powder. This powder forms beautiful red solutions with potass and ammonia: which are capable of being used as a dye on stuffs. Its nature has not been fully examined.

RICE. The name by which rice was known to the ancient Greeks and Romans was *oryza*, and has been adopted by modern botanists as the generic name of the plant yielding that invaluable grain. The genus *oryza* belongs to the class *hexandria*, order *dygynia*; and has ten glumes to a single flower, and two palea, nearly equal, adhering to the seed. It affords many varieties, of which the most common is the *oryza sativa*, or the English rice. This plant is raised in immense quantities in India, China, and most eastern countries; in the West Indies, Central America, and the United States, and in some of the southern countries of Europe. It, in fact, occupies the same place in most intertropical regions as wheat in the warmer parts of Europe, and oats and rye in those more to the north. Forming, as it does, the principal part of the food of the most civilized and populous eastern nations, it is more extensively consumed than any other species of grain. It is light and wholesome, but it is said to contain less of the nutritive principle than wheat. When rough, or in its natural state in the husk, it is called *paddy*. There is an immense variety in the qualities of rice. That which is principally exported from Bengal has received the name of *cargo* rice. It is of a coarse reddish cast, but is sweet and large-grained, and is preferred by the natives to every other sort. It is not kiln-dried, but is parboiled in earthen pots or caldrons, partly to destroy the vegetative principle, so that it may keep better, and partly to facilitate the process of husking. Patna rice is more esteemed in Europe than any other sort of rice imported from the East. It is small-grained, rather long and wiry, and remarkably white. But the rice raised on the low marshy grounds of Carolina is unquestionably very superior to any brought from any part of India.

The produce of lands naturally or artificially irrigated is, as far as rice is concerned, from five to ten times greater than that of dry land having no command of water; and hence the vast importance of irrigation in all countries where this grain is cultivated. But it is worthy of remark, that owing to the not unfrequent occurrence of severe droughts, there is a greater variation in the crops of rice than in those of any other species of grain. Those who, like the Hindoos, depend almost entirely on it for subsistence, are consequently placed in a very precarious situation. There can be no doubt that famines are at once more frequent and severe in Hindostan than in any other quarter.

A few years ago, England was principally supplied with cleaned rice from Carolina. To that country the exports of Carolina rice have been much reduced. An improved method of separating the husk, which throws out the grain clean and unbroken, has recently been practised in England; and as the grain when in the husk is found to preserve its flavor and sweetness better during a long voyage than when shelled, large quantities are now imported rough from Bengal and the United States.

The rice of Carolina, analyzed by Braconnot, was found to be composed of starch 85·07, of gluten 3·60, of gum 0·71, of uncrystallizable sugar 0·29, of a colorless rancid fat like suet 0·13, of vegetable fibre 4·8, of salts with potash and lime bases 0·4, and 5·0 of water.

The plant, in a wild state,. has been found growing in the Northwest territory: in all that country the wild rice is found growing in the lakes and streams.

Some of the seed of this indigenous plant was distributed in in 1849. It has been furnished by Professor Randall, of Cincinnati, who has lately come from the Minnesota territory.

It is considered by him superior in taste, and far more nutritious than the southern rice; it grows abundantly as an indigenous production, and can be cultivated to almost any extent in the rivers and lakes that abound in that territory. After the rice is ready for gathering, the tops are tied up in small sheafs as it stands growing in the water, and then the Indian in his canoe passes through it and beats off the seed into his canoe, by bending over the canoe the tops so that the seed may fall aright. An Indian squaw will gather from five to ten bushels per day. It will grow in water, we are informed, from six inches to five feet deep, when it finds a muddy soil. Its stalk, and the branches or ears that have the seed, are described as resembling oats, both in appearance and manner of growing, the stalks being full of joints and rising from one half to four feet above the level of the water.

Professor Randall is inclined to think that there is as much rice *land* water in Minnesota as in the same area of the States of South Carolina and Georgia, and that the Minnesota rice ground produces as much to the acre, and will at no distant period compete with the southern production. We have tried it boiled as usual, and have found it very palatable.

The specimen, however, in appearance, is not inviting, as the outer skin of the hulled rice is dark colored, though the inside is white as the southern kind. This may be owing to some difficulty in preserving it, and probably if more completely hulled the objection would disappear.

Since the notice made of it by Mr. Randall, it has been further noticed as abundant in the Minnesota territory. Gen. Verplanck, late Commissioner to the Chippewa Indians, pronounces it better than southern rice. The kernels are larger and its flavor is better; for when boiled and stewed, and left to cool, it forms a consistent mass like good wheat bread, and more nutritious. It is stated that very great quantities grow on all the lakes in this northern country. The outlets and bays are filled with it. It ripens in the month of August, and is the main reliance of the Indians, during the winter months, for their sustenance. From this account it would seem that it might be an article worthy of attention, and that possibly it may become known and used in the more eastern states.

The introduction of rice in this country is said to have been owing to one of those trivial occurrences which often exert a powerful influence on a nation's prosperity. It is stated that in the year

1695, a brig from Madagascar, touching at Charleston on her way to England, anchored off Sullivan's Island. The captain invited *Landgrave Smith* on board, and presented to him a bag of seed rice, with information of its growth in the east, and its excellence for food and its amazing increase. The governor divided it among his friends, who made experiments with it, which fully answered expectation, and from this small beginning arose one of the great staple articles of South Carolina and Georgia.

The quantity of rice raised in 1847, amounted to 103,640,590 lbs., the greater part of which was grown in South Carolina: the value of the foregoing quantity was $3,091,215.

The exports of rice from this country, during 1847 and 1848, were to the value of—

1847	$3,605,896
1848	2,331,824

A rice crop is said in produce to equal six times the wheat crop in the same locality. Forty bushels per acre, however, appear to be the usual crop: it requires a warm and wet soil, hence it is so benefited by irrigation.

The mode of irrigation of rice in China is thus described in Fortune's China, a work which contains many interesting particulars relating to Chinese agriculture:—

"*Irrigation in China.*—Rice is grown on the lower terrace ground; and a stream of water is always led from some ravine and made to flow across the sides of the hills, until it reaches the highest terrace, into which it flows, and floods the whole of the level space. When the water rises three or four inches in height, which is sufficiently high for the rice, it finds vent at an opening made for the purpose in the bank, through which it flows into the terrace below, which it floods in the same manner, and soon to the lowest. In this way the whole of the rice terraces are kept flooded continually, until the stalks of the crops assume a yellow ripening hue; when the water being no longer required, is turned back into its natural channel, or led to a different part of the hill for the nourishment of other crops. These mountain streams, which abound in all parts of the hilly districts, are of the greatest importance to the farmer; and as they generally spring from a high elevation in the ravines, they can be conducted at pleasure over all the lower parts of the hill. No operation in agriculture gives him and his laborers more pleasure than leading these streams of water from one place to another, and making them subservient to their purposes. In my travels in the country the inhabitants often called my attention to this branch of their operations; and I pleased them much when I expressed my admiration at the skill with which they executed it. The practice is not confined to the paddy-fields; for I remember once, when superintending the planting of some large trees and shrubs in the garden of Messrs. Dent and Co., in Hong-Kong, after I had given them a large supply of water at the time they were put into the ground, I desired the gardener to repeat the dose next morning. But on the following day, when I returned to the spot, I was surprised to find a little stream divided into many branches, and meandering among the roots of the newly-planted trees. As there was no stream there before, I went to examine its source, and found that it had been led from a neighboring ravine—a work more easy than carrying a large supply of water in buckets, at the same time more effectual."

RICE PAPER. This substance is said to be a membrane of the *Artocarpus incisa*, or bread-fruit tree. It is brought from China in small pieces, dyed of various colors, and is used as a material for painting upon, and for the manufacture of several fancy and ornamental articles. It is sometimes erroneously stated to be prepared from rice.

RIFLE GUNS. Muskets or pieces of ordnance, whose barrels, instead of being a clear cylinder inside, are furrowed with spiral channels. The object is to give the ball a rotatory motion about an axis, in consequence of which it preserves its direction with much greater certainty than when fired from the common clear barrel. (*See* GUN.)

Prussian Breech-Loading Rifle. There is a Prussian rifle, known by the name of the *Zund Nadel* (darting needle). The light infantry of the Prussian army are all armed with this fearful weapon, and in the late war with the Danes, and in some encounters with the people, it proved terribly advantageous on the side of Prussia. It has a number of points about it, very different from all other breech-loading fire-arms, the principal of which are the three following. First, it uses a different cartridge and no detonating powder, but a friction needle—*darting* needle (zund nadel), which pierces the bottom of the cartridge and ignites the powder by a friction combustible priming. All this is done inside, and it is certainly as efficacious in wet as in dry weather. Second, An air chamber behind the cartridge, in which the expanded air acts to force out the ball. It carries a ball 800 yards, and is as effective at that distance as a musket at 150, and in that case, for picking off artillerymen on the field, it was said by a celebrated American General, who beheld its effects, "their occupation 's gone." Third, The sliding breechpin, and the manner of operating and fastening it in an inclined butt of the breech.

RIGIDITY. In mechanics, a resistance to change of form. In all theoretical investigations respecting the application of forces through the intervention of machines, those machines are assumed (except cords) to be perfectly rigid, so far as the forces employed are able to affect their integrity of form and structure. Rigidity is often, in the arts, called *stiffness*, and is opposed to flexibility.

The rigidity of cords, or the difficulty with which they are bent into any given curve, is the chief cause of the loss of power arising from their employment in machines. The law of their loss of force may be thus expressed: The resistance arising from the stiffness of cords is as the weights which stretch the cords multiplied by the thickness of the cords, and divided by the radii of curvature of the surfaces over which they pass. It is however, necessary to state, that experiments exhibit great discrepancies with this theoretical law.

RINGS, FAIRY. This name is given to irregular circles in pastures and lawns on which *Agarics* spring up, and which become much more verdant than the surrounding grass. They are caused by the centrifugal growth of the spawn of the *Agaric*, which radiates from a common centre, and bears the fructification, which is what appears above ground, only at the circumference. The verdure of the grass where these fungi grow seems to be caused either by their manuring the ground when they decay, or by the nitrogen they give off, which is an active stimulant to vegetation. The application of *fairy rings* was given to this phenomenon from their being regarded as the places where the fairies held their nocturnal revels.

ROADS, are pathways formed through a country, by which passengers and commodities may travel, or be transported, with more or less facility and expedition, from one place to another. Roads are of various kinds, according to the state of civilization and wealth of the country through which they are constructed, and according to the nature and extent of the traffic to be carried on upon them, from the rude paths of the aboriginal people, carried in direct lines over the natural surface of the country, passable only by foot passengers or pack-horses, to the comparatively perfect modern road, carried on an artificial causeway, and reduced to a nearly level surface at enormous expense by means of vast excavations, extensive embankments, bridges, viaducts, tunnels, and other expedients supplied by the skill and ingenuity of the civil engineer.

Advantages of Roads.—There is no expedient which more powerfully conduces to the advancement of a people in civilization, or to the extension of their prosperity and national wealth, than the construction of good roads, connecting the various centres of commerce and of industry about which they may have collected themselves. The invention of printing, the expedient of money, the adoption of a uniform system of weights and measures, would severally be ineffectual, or productive of advantages of a very limited extent, if the intercommunication of those whose feelings and ideas are expressed and conveyed in print, and among whom money is made to circulate, and whose commerce is stimulated and facilitated by the uniform module of quantity supplied by weights and measures, were not facilitated and expedited by the means of conveyance supplied by roads. Without roads, the interchange of advantages, moral, intellectual, and physical, which now takes place in all highly civilized countries between the rural and the urbane population, could not be maintained; without them, indeed, large towns or cities could not continue to exist. The supply of the population collected in such places, with the various products of agriculture, necessary to their physical existence, could not be sustained. Nor, on the other hand, would the rural population affording that supply be benefited by a return in exchange of the refinements of the town, and the various articles of luxury and necessity obtained by commerce from every part of the globe.

But roads are not less necessary for the advancement of agriculture itself, than for the due maintenance of the necessary relations between the towns and the country. Without the aid of roads, it would be impossible to apply those arts to the soil by which increased powers of production are given to it. Without roads, the various kinds of manure, by which the scientific farmer knows how to raise augmented crops, could not be transported to his fields from the place, often distant and difficult of access, where such manures are found. Roads may then, in fact, be considered as a system of veins and arteries, by which all those principles necessary for the maintenance of the prosperity of a country are kept in circulation.

The Art of Road-making.—When it is proposed to construct a line of road extending between two places, the engineer upon whom such a duty devolves, first makes himself well acquainted with the surface of the country lying between the two places, so as to obtain an acquaintance with the face of the country, somewhat approaching to that which would be supplied by a superficial model of it, which would exhibit all its inequalities and undulations of surface. He is then to select what he considers, all circumstances being taken into account, the best general route for the proposed road. But, previously to laying it out with accuracy, it is necessary to make an instrumental survey of the country along the route thus selected; taking the levels from point to point throughout the whole distance, and making borings in all places where excavations are required, to determine the strata through which such cuttings are to be carried, and the requisite inclinations of the slopes or slanting sides, as well of the cuttings as of the embankments to be formed by the material thus obtained. It is also requisite, in the selection of the route for the proposed road, to have regard to the supply of materials, not only for first constructing it, but for maintaining it in repair; thus, the position of gravel pits and quarries in the neighborhood of the proposed line, and the modes of access to them, should be well ascertained.

The results of such an investigation should be reduced to a plan and section; the plan of the road being on a scale not less than 66 yards to an inch, and the section not less than 30 feet to an inch.

The loss of tractive power, and danger to travellers produced by steep acclivities, render it especially necessary that a proper limitation should be imposed upon the inclinations or acclivities on every line of road on which much traffic is carried on. As, however, this reduction of hills in a country where much inequality of surface exists is attended with a considerable outlay of capital, the engineer will have to balance the cost of constructing a road, having the best possible inclinations against the advantages to be obtained in the permanent working of the road; and if the expected traffic be not such as to yield advantages proportionate to the capital absorbed, greater rates of inclination must be allowed to the hills, with a view to diminish the extent of the works, and to render the expense of constructing the road proportionate to the traffic expected upon it.

A dead level, even where it can be obtained, is not the best course for a road; a certain inclination of the surface facilitates the drainage, and keeps the road in a dry state. There is a certain inclination, depending on the degree of perfection given to the surface of the road, and on the structure of the carriages worked upon it, which cannot be exceeded without a direct loss of tractive power; this inclination or acclivity is that, in descending which, at a uniform speed, the traces slacken, or which causes the carriages to press on the horses: the limiting inclination within which this effect does not take place is called the *angle of repose*.

On all acclivities less steep than the angle of repose, a certain amount of tractive force is necessary in the descent as well as in the ascent; and the mean of the two drawing forces, ascending and descending, is equal to the force along a level road. Thus, on such acclivities as much power is gained in the descent as is lost in the ascent; but on acclivities which are more steep than the angle of repose, the load presses on the horses during their descent, so as to impede their action, and their power is expended in checking the descent of the load: or, if this effect be prevented by the use of any form of drag or break, then the power expended on such drag or break corresponds to an equal quantity of mechanical power expended in the ascent, for which no equivalent is obtained in the descent.

On well-constructed roads, with carriages such as now are generally used in England, the angle of repose may be taken at about one in thirty-six: and this is consequently an acclivity which ought not to be exceeded on roads over which much traffic is carried.

The expedients by which the requisite inclinations are obtained on common roads are the same as those which are resorted to in the construction of railways. (*See* RAILROADS.)

The exact course of the road, and the degree of its acclivities being determined, the next thing to be considered is the formation of its surface. The qualities which ought to be imparted to it are two-fold—first, it should be smooth; secondly, it should be hard; and the goodness of the road will be exactly in the proportion of the degree in which these qualities can be imparted to it, and permanently maintained upon it. An error prevailed among road engineers until a very recent period. It was considered that smoothness of surface alone was sufficient for the perfection of a road; and that, provded it could be made sufficiently durable, it was unimportant how soft or yielding the coating of the road might be. This error, into which, among others, Macadam himself fell, was based upon a neglect of one of the most important circumstances to be considered in the construction of a road. The main object to be attained by all roads is the diminution of the resistance which a carriage opposes to the tractive power. Other things being the same, it was sufficiently apparent that this resistance would be diminished by increasing the smoothness of the road surface. But roughness or unevenness of surface is not the only cause of resistance to the tractive power; if two roads have their surfaces equally smooth and even, but one is soft and elastic, so as to yield under the pressure of the wheel, recovering its form as the wheel advances, and the other is hard and unyielding, the resistance to the tractive power will be greater on the soft and yielding road than on the hard and unyielding road; and this augmentation of resistance will be in proportion to the softness of the surface. That this would be the case, admits of immediate demonstration on mechanical and mathematical principles; but, without resorting to these, it must be sufficiently apparent from the results of the most common experience. A surface of velvet may be as smooth and even as a surface of ice; but if an ivory ball be rolled on the latter, it will continue its motion much longer than on the former. In fact, the wheels of a carriage in passing along a soft road sink into its surface, as the ball would sink into the pile of the velvet; and although, in virtue of its elasticity, the surface of the road, like that of the velvet, may recover its smoothness after the pressure has been removed from it, still a resistance will be offered to the drawing or impelling power, which would not be produced by a hard and unyielding surface equally smooth.

Macadamization.—This process, which has received its name from Macadam, to whose labors the improvement of the roads of England within the last half century owes so much, consists in forming the road crust of stones, broken with a hammer into angular pieces of a small and uniform size. This method, however, is one which was long practised in various parts of Europe. When the stones of which the road crust is to be formed are broken to the proper magnitude and form, they are spread over the surface of the road in a layer of three or four inches thick. After this has been consolidated by carriages working upon it or by rollers, another layer of broken stones of equal depth is laid upon it; it is consolidated in like manner; and thus one layer is laid over another until an artificial crust is formed of broken stones of sufficient thickness to give the requisite strength to the road.

A coating or road crust thus formed might be constructed on any substratum whatsoever, and a smooth and apparently good road would be obtained. It was the practice of Mr. Macadam to disregard the nature of the substratum; and he maintained that if it was not such a bog as would not allow a man to walk over it, he would even prefer it to a hard bottom.

Telford's System.—The improvement in road-making, which consists in a due attention to the substratum or foundation of the road, so as to give increased facility to the tractive power by rendering its surface hard and unyielding, is due to the late Mr. Telford. The following is a description of the method of constructing such a road practised by that eminent engineer.

Upon the level bed, prepared for the road materials, a bottom course or layer of stones is to be set by hand, in form of a close firm pavement. The stones set in the middle of the road should be 7 inches in depth; at 9 feet from the centre the depth should be 5 inches; at 12 feet, 4 inches; and at 15 feet, 3 inches; the entire width of the road being 30 feet. These stones are to be set on their broadest edges lengthwise across the road, and the breadth of the upper edge should not exceed 4 inches. All the irregularities of the upper part of this pavement are to be broken off by hammers, and all the interstices to be filled with stone chips firmly wedged or packed by hand with a light hammer; so that, when the pavement is finished, its cross section shall have a convexity of surface of about 4 inches in the centre above the extreme edges; 18 feet in the centre of this pavement are to be coated with a layer of hard broken stones, 6 inches deep; of these 6 inches, 4 must be first put on and worked down by carriages and horses in the ordinary traffic of the road, care being taken constantly to rake in the ruts until the surface has become firm and the crust consolidated. After this, the remaining 2 inches of stone may be put on: the whole of this stone, forming 6 inches of crust, is to consist of pieces broken as nearly as is practicable into a cubical form, and of such a magnitude that they can pass through a ring of 2½ inches internal diameter. The spaces on each side of the middle 18 feet are to be coated with broken stone or well-cleansed stone gravel up to the level of the footpath, or other boundary of the road, so as to make the whole convexity of the road 6 inches in the middle above the level of the edges; and the whole of the materials thus formed and consolidated, should be covered with a coating 1½ inches deep of good gravel, free from clay or earth.

Under the article PAVEMENT *for roads*, the Russ and Perrine pavements put down in New-York are described. These are in part based on Telford's plan, and are enduring roads. In 1850, a part of Broadway was paved thus: there was an excavation made to the depth of 2 feet, and coarse flagstone 2 feet by 3 laid down. The seams were filled in by hot pitch covered by gravel, and above this a layer of broken road metal was laid smoothly, and the whole overtopped with large granite blocks, about the size used for Russ pavement. There can be no question about the enduring qualities of this pavement, but the large blocks on top are objectionable, for when worn smooth they become dangerously slippery. Neither is it convenient, when a necessity arises to open the street to get at the gas or water pipes. Top blocks of half the size would answer a better purpose; where a firm foundation is used the top tier need not be so large. On these roads the superficial wear is but slight, and much of the dust of summer and mud of winter is obviated. Such is the structure which is requisite for the streets which are the main thoroughfares of a great city; a pavement with less strength of foundation, and formed of smaller blocks of stone, being used for the streets of less intercourse.

To many inconveniences produced in the great thoroughfares of this or any other large city, along which heavy stages travel, by reason of the rapid wear of every kind of pavement hitherto adopted, a suspension of the intercourse during the frequent repairs, the dust in summer and the mud in winter, produced by a surface of broken stones, and the intolerable noise produced by every species of stone pavement, have lately excited much inquiry as to the possibility of constructing some road having sufficient strength for a traffic so enormous, sufficient durability to prevent the inconvenience of the frequent suspension of intercourse by the necessity of repairs, and presenting a surface which, while it would be free from the noise of a stone pavement, would not be attended with the inconvenience of dust and mud produced by a surface of broken stone. This problem appears to be in a great degree solved by the adoption of a pavement of wood. A short piece of Oxford Street, London, was paved in the beginning of 1839; and after a successful trial of several months, the same pavement was extended nearly throughout the whole extent of that street; and up to the year 1846, this method of pavement was in process of construction in several other thoroughfares of London. The idea of a wooden pavement is not new. In the northern parts of Germany and in Russia such pavements have been long in use; some of the main streets of Petersburgh and Vienna have long been paved in this manner. A few years ago a series of experiments were made at New York, to determine the best description of paving for a street. One of the methods adopted was a tesselated pavement, formed of hexagonal blocks of pine wood, measuring 6 inches on each side of their transverse section, and 12 inches in depth. From the manner in which the timber is cut, its fibres are vertical, and therefore the tendency to wear from vertical pressure is small. The blocks are coated with pitch or tar, forming a smooth upper surface.

Various methods have been proposed for laying the wood pavements of London; but as these methods have been tried and found objectionable, it is unnecessary to do more than notice them here. There appears, however, still sufficient to justify a well-grounded expectation that wood pavements of some form or other will soon supersede all others for great thoroughfares of towns.

In constructing roads it is far better to make them as level as possible at first, and rather go round than up the hills. It is calculated that the power of a horse, on a level, averages 1,000 lbs., at a moderate pace, and in a rise of 1 in 100 feet he can draw only 900; 1 in 50, 810; 1 in 44, 750; 1 in 40, 720; 1 in 30, 640; 1 in 26, 540; 1 in 24, 500; 1 in 20, 400; 1 in 10, 250. In round numbers, upon a slope of 1 in 44, or 120 feet to the mile, a horse can draw only three-quarters as much as he can upon a level; on a slope of 1 in 24, or 220 feet to a mile, he can draw only half as much; and on a slope of 1 in 10, or 528 feet to the mile, only one-quarter as much. Though a horse on a level is as strong as five men, yet on a steep hill it is less strong than three; for three men, carrying each 100 lbs., will ascend faster than a horse with 300 lbs. The popular theory, that a gentle undulating road is less fatiguing to horses than one which is perfectly level, is pronounced erroneous.

Mr. Bevan has published results of some experiments on the actual force of draught of carriages upon common roads, all made, or reduced to roads perfectly level or horizontal, to separate the mechanical force due to the inclination of the hill or plane from the force necessary to overcome the friction of the carriage, in its ordinary state, as affected by the condition of the road; and, by way of rendering them comparable with other experiments, which have been, or may yet be, made on this subject, he considered the gross load of the wagon and burden to be divided into 1000 parts.

Loose sandy road, force of draught 204 or 1-5th.

Turnpike-road, new gravelled, mean 143 or 1-7th.

Ordinary bye-road, mean 106, nearly 1-9½th.

Hard compact loam, mean 53, nearly 1-19th.

Dry hard turf, mean 40 or 1-25th.

Turnpike-road, with a little dirt, mean 34½ or 1-29th.

Turnpike-road, free from dirt, mean 30½ or 1-33d.

From which it appears that *five* horses will draw with equal ease the same load upon a good hard turnpike-road, as ***thirty-three*** horses can do upon loose sand! Or, if we assume the value of draught, upon a well-formed road in good condition, at sixpence per ton per mile, the equivalent price will be

	s.	*d.*
Upon hard turf	0	7¼
" **hard loam**	0	9½
" **ordinary bye-road**	1	7
" **newly gravelled road**	2	2
" **loose sandy road**	3	1

On hard smooth roads the forces are required to be as the angle of inclination, nearly; but when the wheels sink, they have to overcome the enlarged angle created by the cavity, in relation to the level ground which follows.

He has published a table, containing the results of experiments made upon *the hardness of road materials*, or their power of resisting the percussion of a given weight of cast-iron, falling a few inches upon the several specimens broken to the ordinary size, and resting upon stone or iron. Supposing the weather to have no action, the table would express nearly the relative value of the materials, for the purpose of supporting the wear of a road; and, therefore, those which resist the action of frost and weather, and have the highest numbers, are most valuable.

Sienite	100
White marble	37·31
Chert pebble, Middlesex	34·27, 52·56, 55·65
Quartz pebble	70
Ferruginous sandstone	20·42
Hurlock from lower chalk	10
Chalk	3
Granite	110
Flint, yellow	33·26
Greenstone	110
Sandstone, soft	13·6
Tile fragment	20
Gritstone, near Brixworth	48 60
Limestone, near Bradwall	5
Dry clay	12
Flint, black	11 30
Portland stone, hard	14
Quartz, white	56
Blue pebble, like Rowley rag	105·110
Coarse limestone, near Stilton	60
Gritstone, near Leeds	100·115
Yorkshire paving-stone	20
Ketton, hard	20
Tetternhoe	4
Chert	57
Gray wether, Herts and Wilts	18
Grit of upper bed, Collymeston	40
Second bed, ditto	100
Slate at ditto	50
Stockton limestone, (lias)	45
Newbold, on Avon, ditto	86
Limestone of Stoke Cruerne	85
Copper slag	248

The steady pressure, without percussion, required to crush a piece of the marble, weighing half an oz., was 100 lbs.; to crush the grey flint, of 1·2 oz. weight, 2000 lbs.; to crush the rolled white quartz pebble, of 2 oz. weight, 3400 lbs.

ROCHELLE SALT. The tartrate of soda and potassa. It is a double salt, composed of 2 equivalents of tartaric acid (66 + 2) = 132, 1 equivalent of potassa = 48, and 1 of soda = 32. Its crystals, which are large and well-defined prisms, often presenting eight, ten, or twelve sides, include 8 equivalents (9 × 8) = 72 of water.

It is formed by dissolving 20 ounces of carbonate of soda in 10 wine pints of water, and adding, gradually, 20 ounces of cream of tartar, filtering the solution, evaporating it to a skin, and crystallizing.

ROCK SALT. Common salt found in masses or beds in the new red sandstone, as in Cheshire and elsewhere.

ROCKET. (*See* PYROTECHNY).

ROD, in brick-work, is a superficies of 272 square feet, 1½ brick thick, and containing about 4500 bricks, and from 90 to 100 bushels of mortar. The cubic rod is 272 × 1·125 or 306 feet. It is 4 or 5 days' work for the man and laborer.

ROLLING, in mechanics, is when all the parts of the surface of one body come into successive contact with those of another, and under such conditions as that, at every instant, the portion of the two surfaces which *have been* in contact are exactly equal. When this condition is not fulfilled, the one surface is said to slide upon the other. The friction of bodies in rolling is much less than in that of sliding; and hence the advantage of wheels to all kinds of carriages.) (*See* FRICTION.)

ROLLING. In Naval language, the lateral oscillation of a vessel. This motion, which is often very great when the vessel is running before the sea, endangers the masts, strains the sides, and loosens the decks at the waterways; it is also liable to cause the guns to break adrift. When the centre of gravity is too low, the oscillations begin and end violently. The changes in the stowage necessary to modify the nature or extent of the roll are made by seamen from experimental knowledge.

ROLLING PENDULUM. A cylinder caused to oscillate in small spaces on a horizontal plane. Its mathematical expressions are interesting, but it has been applied to no important practical purpose.

ROLLING TACKLE. **A tackle or pulley hooked to the weather quarter of a yard. and to a lashing or strap round the mast near the slings or parral of the yard; the object of it is to keep the yard constantly over to leeward, thereby depriving it of play and friction when the ship rolls to windward.**

ROMAN ALUM. **An alum extracted from the volcanic rock of the Solfaterra near Naples: it crystallizes in opaque cubes, and appears to contain more alumina than the common octohedral alum.**

ROOF. In architecture, the uppermost part of a building, containing the timber work, with its covering of slate, lead, tile, or other material. Carpenters, however, restrict their use of the word to the timber framing alone.

The inclination of the sides of a roof will, considering the species of covering to be the same in all, depend very much on the temperature of the country to which it is to be adapted. In the southern and warm countries roofs do not require much elevation, while as we proceed northward they require a far greater pitch. In the warm, or, rather, hot climates, buildings require nothing more than a terrace for their covering; but in the temperate climates, wherein the latitude exceeds 42°, experience shows that the flat covering of a building cannot be practised with any expectation of durability. The rains of hot climates are violent, while those of temperate climates are searching. In the more northern latitudes, the moisture, the driving nature of the rain, and, in addition, the duration of the snow on the roofs, require, it is obvious, a more considerable inclination. Such materials as lead, copper, zinc, and the like, which, supposing them one piece, as, in fact, when used, they ought to be, are not fair examples from which to draw inferences in the theory whereof we speak; for, if well executed, they must either of them be considered as one homogeneous piece: but in the case of tiles, whether of marble, stone, or clay, the case is far different. Without entering minutely into the details of this subject, we will merely observe that, supposing the inclination of a roof to be zero at the equator, if we add to it an inclination of three degrees for every climate from the equator to the polar circle, each climate being taken at 2° 42′ 30″, we obtain results which show that the roofs and pediments of temples of antiquity must have been well studied in that useful point of view which regarded their durability and impenetrability by rain. The theory would give an inclination to roofs at Athens of 16½°, and they are very nearly so inclined; the temple of Minerva being 16°, and that of the temple of Eretheus 15½°. In Rome, according to this theory, the inclination of a roof, and, consequently, pediment, should be 22°; and experience finds it varying from 23° to 24½°. The advocates for the propriety of strictly copying Greek forms and details under the latitude of London will, if they have studied the æsthetics of the art, find no little difficulty in establishing their doctrines after weighing this matter impartially. But our limits prevent farther observation: we will merely subjoin a table conformable to the theory:

Place.	Latitude to nearest Minute.		Length of longest Day.		Inclination of Roof, supposing Covering to be Roman Tiles.	
Carthagena	37°	36′	14h.	42m.	19°	12′
Palermo .	38	7	14	48	19	48
(Latitude of Athens is 38° 5′) . . .	.	.	.	.	(see above.)	
Lisbon . .	38	42	14	50	20	0
Madrid . .	40	25	15	0	21	0
Naples .	40	50	15	2	21	12
Rome . .	41	54	15	10	22	0
Paris . .	48	50	16	6	27	36
London . .	51	31	16	34	30	24
Amsterdam	52	22	16	44	31	24
Edinburgh .	55	57	17	32	36	12
Petersburgh	59	56	18	44	43	24

A roof as respects its construction, involves some knowledge of mathematics. Of the general principles on which its proper construction depends, we shall here subjoin some account. The obvious mode of covering a building, where a greater or lesser inclination of the sides of the roof is required by the climate, is to place two sloping rafters upon the walls. If the walls be not of sufficient weight, the thrust that will be thus exerted on them by the tendency of the rafters to spread at their feet will throw the walls out of an upright, and the whole assemblage will be destroyed. By the laws of mechanics it is known that the horizontal thrust thus acting on the walls is proportional to the length of a line drawn at right angles to the rafter, intersecting a vertical line drawn from the apex, which it is manifest must increase as the roof becomes flatter. To counteract the thrust above mentioned, nothing more is necessary than to tie together the feet of the rafters by a *tie beam*. If the extent be not very great, the rafters may be kept from spreading by a minor tie, called a *collar*. Beyond certain lengths or spans, however, it will occur to the reader that a tie-beam will itself have a tendency to bend, or sag, as the workmen call it, in the middle; and from this circumstance a fresh contrivance becomes necessary, this is called a *king-post*, or, more properly, *king piece*, inasmuch as it does not perform the office of a post, but rather of a tie, for it ties up the beam to prevent its bending. If the rafters be so long as to be liable to bend, two pieces called *struts*, are introduced; which, having their footing against the sides of the king post, act as posts to support or *strut up* the rafters at their weakest point. The piece of framing thus contrived is altogether called a *truss*. It is obvious that by means of the upper joints of the struts we obtain more points of support, or rather suspension; and that but for the compressibility of the timber, there would be no limit to the space which a roof might be made to cover. This compressibility takes place at those points where the fibres of the wood are pressed at right angles, or nearly so, with their direction, and many ways are adopted for avoiding this inconvenience. The *curb* or *mansard* roof is one in which a story is obtained. Its principles are the same as those already mentioned, and do not here require farther notice. In the execution of roofs the expense of trussing every pair of rafters would be unnecessary, and the practice would also load the walls with a far greater weight than would be expedient: it is therefore the custom to place these *principal* parts of a roof at certain intervals, which, however, should never exceed ten feet. The rafters which are actually trussed are called *principal rafters*; and by the intervention of the *purline* are made to bear the smaller or common rafters, which are notched down on it. These common rafters are received by or pitch upon a plate called a *pole-plate*; and the principal rafters, which fall on the tie-beam, are ultimately borne by the wall-plate.

When beams, in either roofs or floors, are so long that they cannot be procured in one piece, two pieces to form the required length are *scarfed* together, by indenting them at their joints and bolting them together, of which practice two modes are here subjoined.

ROPE-MAKING. The fibres of hemp which compose a rope, seldom exceed in length three feet and a half, at an average. They must, therefore, be twined together so as to unite them into one; and this union is effected by the mutual circumtorsion of the two fibres. If the compression thereby produced be too great, the strength of the fibres at the points where they join will be diminished; so that it becomes a matter of great consequence to give them only such a degree of twist as is essential to their union.

The first part of the process of rope-making by hand, is that of spinning the yarns or threads, which is done in a manner analogous to that of ordinary spinning. The spinner carries a bundle of dressed hemp round his waist; the two ends of the bundle being assembled in front. Having drawn out a proper number of fibres with his hand, he twists them with his fingers, and fixing this twisted part to the hook of a whirl, which is driven by a wheel put in motion by an assistant, he walks backwards down the rope-walk, the twisted part always serving to draw out more fibres from the bundle round his waist, as in the flax-spinning wheel. The spinner takes care that these fibres are equably supplied, and that they always enter the twisted parts by their ends, and never by their middle. As soon as he has reached the termination of the walk, a second spinner takes the yarn off the whirl and gives it to another person to put upon a reel, while he himself attaches his own hemp to the whirl hook, and proceeds down the walk. When the person at the reel begins to turn, the first spinner, who has completed his yarn, holds it firmly at the end, and advances slowly up the walk, while the reel is turning, keeping it equally tight all the way, till he reaches the reel, where he waits till the second spinner takes his yarn off the whirl hook, and joins it to the end of that of the first spinner, in order that it may follow it on the reel.

The next part of the process previous to tarring, is that of warping the yarns, or stretching them all to one length, which is about 200 fathoms in full-length rope-grounds, and also in putting a slight turn or twist into them.

The third process in rope-making, is the tarring of the yarn. Sometimes the yarns are made to wind off one reel, and, having passed through a vessel of hot tar, are wound upon another, the superfluous tar being removed by causing the yarn to pass through a hole surrounded with spongy oakum; but the ordinary method is to tar it in skeins or hanks, which are drawn by a capstan with a uniform motion through the tar-kettle. In this process, great care must be taken that the tar is boiling neither too fast nor too slow. Yarn for cables requires more tar than for hawser-laid ropes; and for standing and running rigging, it requires to be merely well covered. Tarred cordage has been found to be weaker than what is untarred, when it is new; but the tarred rope is not so easily injured by immersion in water.

The last part of the process of rope-making, is to lay the cordage. For this purpose two or more yarns are attached at one end to a hook. The hook is then turned the contrary way from the twist of the individual yarn, and thus forms what is called a strand. Three strands, sometimes four, besides a central one, are then stretched at length, and attached at one end to three contiguous but separate hooks, but at the other end to a single hook; and the process of combining them together, which is effected by turning the single hook in a direction contrary to that of the other three, consists in so regulating the progress of the twists of the strands round their common axis, that the three strands receive separately at their opposite ends just as much twist as is taken out of them by their twisting the contrary way, in the process of combination.

Large ropes are distinguished into two main classes, the *cable-laid* and *hawser-laid*. The former are composed of nine strands, namely, three great strands, each of these consisting of three smaller secondary strands, which are individually formed with an equal number of primitive yarns. A cable-laid rope eight inches in circumference, is made up of 888 yarns or threads, equally divided among the nine secondary strands. A *hawser-laid* rope consists of only three stands, each composed of a number of primitive yarns, proportioned to the size of the rope; for example, if it be eight inches in circumference, it may have 414 yarns, equally divided among three strands. Thirty fathoms of yarn are reckoned equivalent in length to eighteen fathoms of rope cable-laid, and to twenty fathoms hawser-laid. Ropes of from one inch to two inches and a half in circumference are usually hawser-laid; of from three to ten inches, are either hawser or cable-laid; but when more than ten inches, they are always cable-laid.

Dr. Ure gives the following relative strength of cordage, shroud-laid:—

Size.	Warm Register.				Cold Register.				Common Staple.			
	Tons.	Cwts	Qrs.	Lbs.	Tons.	Cwts.	Qrs.	Lbs.	Tons.	Cwts.	Qrs.	Lbs.
3 inches bore	3	17	—	16	3	5	3	16	2	9	1	24
3½ "	5	5	—	—	4	9	2	21	3	6	1	27
4 "	6	17	—	16	5	17	—	4	4	5	3	7
4½ "	8	13	2	8	7	5	3	1	5	1	2	6
5 "	10	14	1	4	9	3	—	4	6	9	2	8
5½ "	12	19	2	4	11	1	1	25	7	12	—	22
6 "	14	15	2	24	13	3	2	8	8	17	1	20
6½ "	18	2	—	10	15	9	1	9	9	16	3	14
7 "	21	—	—	—	17	18	3	8	11	4	1	21
7½ "	24	2	—	16	20	11	3	9	12	8	3	6
8 "	27	8	1	26	23	8	2	8	13	2	3	12

A test trial, of Manilla and Kyanized American rope, was had at Griffey's Foundry, Cincinnati, which resulted most favorably to the American manufacture. A small Manilla rope, of the best quality of Boston make, was first tried, and was broken, after sustaining a weight of 1520 pounds. The Kyanized rope, invented and manufactured by J. T. Crook & Co., of Maysville, was then put to the same test, and sustained a weight of 2,820 pounds before parting. A second trial was then had of the same size of Manilla rope, which sustained a weight of 2,200 pounds. A second trial was then also had of the Kyanized rope, and sustained a pressure of 2,410 pounds. Two trials were then had with a larger size of the Manilla rope, manufactured by Bonte, which parted first at 2,840 pounds, and on the second trial at 2,796 pounds. One trial was then made with the Kyanized rope, which sustained the weight of 3,220 pounds before parting. The average difference in favor of the Kyanized unrotted hemp rope being in the first trials 500 pounds, and in the last trial 400 pounds. This shows that the Manilla rope, which has always been considered the best that was ever used, is far inferior to the American unrotted hemp rope. The Kyanized rope is manufactured from the unrotted hemp, and is not only the strongest rope made, but by the chemical process of Kyanizing, is by far the most durable. (*See* HEMP.)

ROSE ENGINE. In mechanics, an appendage to the turning lathe, by which a surface of wood or metal, as a watch-case, is engraved with a variety of curved lines. The assemblage of these lines presenting some resemblance to a full-blown rose, is called by the French *rosette*; and hence the engine by which the ornament is produced is called a rose-engine. The mechanism by which the figures are produced is sometimes called a *camb*, and may be described as follows: 'A wheel upon the axle turns uniformly in one direction. A rod moves in guides, which only permit it to ascend and descend perpendicularly. Its extremity rests upon a path or groove raised from the face of the wheel, and shaped into such a curve that as the wheel revolves the rod shall be moved alternately in opposite directions, through the guides, with the required velocity. The manner in which the velocity varies, will depend on the form given to the groove or channel raised upon the face of the wheel; and this may be shaped so as to give any variation to the motion of the rod which may be required for the purpose to which it is to be applied.

The purpose of the machine is therefore to convert a uniform rotatory movement into a varied rectilinear and alternating movement. It is also used in machinery for spinning, and for lace-making.

ROSIN, or COLOPHONY is the mass left after distilling off the volatile oil from the different species of turpentine. Yellow rosin contains some water, which black rosin does not. (*See* TURPENTINE.)

ROSIN GAS. Illuminating gas made from rosin was, until lately, manufactured largely in New-York and other cities. It furnishes a very pure gas, but cannot be made as cheaply as that from coal. The apparatus used in the manufacture of oil gas is adapted for that of rosin gas. (*See* OIL GAS.) Mr. Daniel, of London, prepared an apparatus for this end which is as follows:

The melted rosin having passed by the stopcock, funnel, and syphon, into the retort, falls on the coke, and in its passage through the ignited mass, becomes decomposed. On arriving at the other end of the retort, a large portion of the oil of turpentine, in the form of condensable vapor, is separated by the refrigerator; this is supplied with water from a cistern above, and the non-condensable vapor or gas passes up the tube and dips beneath the surface of the fluid in the main. This completes the condensation; and the gas proceeds in a perfectly pure state, by a pipe, to the gasometer, or rather to the floating reservoir, for use.

The essential oil, when it leaves the refrigerator, is conveyed, by the syphon, to a cistern beneath. The necessity for employing a syphon will be apparent, when it is borne in mind that the tube prevents the escape of the gas, which would otherwise pass away from the box with the essential oil. Another pipe and syphon serve to convey the condensed essential oil from the top cistern.

ROTARY ENGINE. An apparatus of this kind has been invented by Capt. Hon. W. E. Fitzmaurice, and a Mr. Hartford. It is described as "very simple, merely consisting of two pieces so mathematically arranged that the interior part works in the outer with the greatest ease, being free from dead points and without the slightest vibration, however great the velocity. It has no springs or packing, and the parts meet each other so harmoniously as only to give a humming noise like a spinning top, and it is not in the least liable to get out of order, the wear being perfectly uniform throughout. The entire motion being a rolling instead of a cutting one, the engine will last long without repair, as the surfaces become case-hardened in a very short space of time. The trials took place in the presence of several scientific gentlemen and engineers of eminence in their profession, in a frigate's pinnace, the engine being constructed for the Government."

It also states that it propelled a boat of 80 tons burden at the rate of 8 miles per hour, with a screw, and that an engine of 100 horse power, would only take up a space of 4 by 2 feet. We venture to say that the Hon. Fitzmaurice's rotary engine will soon be numbered with the things that were.

ROTTEN STONE. (*See* TRIPOLI.)

ROUGE. The only cosmetic which can be applied without injury to brighten a lady's complexion, is that prepared from safflower (*Carthamus tinctorius*). The flowers, after being washed with pure water till it comes off colorless, are dried, pulverized, and digested with a weak solution of crystals of soda, which assume thereby a yellow color. Into this liquor a quantity of finely carded white cotton wool is plunged, and then so much lemon juice or pure vinegar is added as to supersaturate the soda. The coloring matter is disengaged, and falls down in an impalpable powder upon the cotton filaments. The cotton, after being washed in cold water, to remove some yellow coloring particles, is to be treated with a fresh solution of carbonate of soda, which takes up the red coloring matter in a state of purity. Before precipitating this pigment a second time by the acid of lemons, some soft powdered talc should be laid in the bottom of the vessel, for the purpose of absorbing the fine rouge, in proportion as it is separated from the carbonate of soda, which now holds it dissolved. The colored mixture must be finally triturated with a few drops of olive oil, in order to make it smooth and marrowy. Upon the fineness of the talc, and the proportion of the safflower precipitate which it contains, depend the beauty and value of the cosmetic. The rouge of the above second precipitation is received sometimes upon bits of fine-twisted woollen stuff, called *crepons*, which ladies rub upon their cheeks.

RUBY. (*See* LAPIDARY.)

ROUGH-CAST. In architecture, the plastering of walls with mortar and fine gravel, left rough without any smoothing.

ROUGH STUCCO. In architecture, stucco floated and brushed in a small degree with water.

RULES, BRASS. Pieces of brass of different thicknesses made letter high, to print with. They are made in lengths of fourteen inches, but of late years lengths half as long again have been made. One of the edges is bevelled so as to print a fine line, and when a thicker line is required the bottom edge is placed uppermost, which is the full thickness of the brass; by this means lines of different thicknesses are obtained, and also double lines, a thick one and a fine one, when required. They are used for column lines in table work; to separate matter that requires to be distinct; and to be placed round pages.

In cases where diagrams are required, and there is no engraver within reach, they may be formed by a clever workman with brass rule. Of late years many ingenious and elaborate imitations of architectural drawings of buildings, with pillars, &c. have been made with brass rule.

RULE, CARPENTER'S. A folding ruler, generally used by carpenters and other artificers, having a variety of scales adapted to facilitate the calculations of most frequent occurrence by inspection. Sometimes it has a sliding piece in one of its legs, by which its use is greatly extended.

RULE, GAUGING, is a rule adapted in the same manner to discover the contents of casks and other vessels. It is used by the officers of excise in surveying the articles in the process of manufacture that are liable to duties.

RUTILITE. Native oxide of titanium.

RYACOLITE. A name given to glassy feldspar.

RYE, according to some, is a native of Crete; but it is very doubtful if it be found wild in any country. It has been cultivated from time immemorial, and is considered as coming nearer in its properties to wheat than any other grain. It is more common than wheat in many parts of middle Europe; being a more certain crop, and requiring less culture and manure. It is the bread corn of Germany and Russia. In Britain it is now very little grown, being no longer a bread corn; and therefore of less value to the farmer than barley, oats, or peas.

SACCHAROMETER is the name of a hydrometer, adapted by its scale to point out the proportion of sugar, or the saccharine matter of malt, contained in a solution of any specific gravity. Brewers and distillers sometimes denote by the term gravity, the excess of weight or 1,000 parts of a liquid by volume above the weight of a like volume of distilled water; so that if the specific gravity be 1,045, 1,070 1,090, &c., the gravity is said to be 45, 70, or 90; at others, they denote the weight of saccharine matter in a barrel (36 gallons) of worts; and again, they denote the excess in weight of a barrel of worts over a barrel of water, equal to 36 gallons, or 360 pounds. This and the first statement are identical, only 1,000 is the standard in the first case, and 360 in the second.

The saccharometer now used in England by the trade, is that constructed by Mr. R. B. Bate, well known for the accuracy of his philosophical and mathematical instruments. The tables published by him for ascertaining the values of wort or wash, and low wines, are preceded by explicit directions for their use. "The instrument is composed of brass; the ball or float being a circular spindle, in the opposite ends of which are fixed a stem and a loop. The stem bears a scale of divisions numbered downward from the first to 30; these divisions, which are laid down in an original manner, observe a diminishing progression according to true principles; therefore each division correctly indicates the one thousandth part of the specific gravity of water; and, further, by the alteration made in the bulk of the saccharometer at every change of poise, each of the same divisions continues to indicate correctly the said one thousandth part throughout."

Dr. Ure prefers to take specific gravities of all liquids whatever with a glass globe containing 500 or 1,00 grains of distilled water at 60° Fahr., when it is closed with a capillary-bored glass stopper; and with the gravity so taken, to look into a table constructed to show the quantity per cent. of sugar, malt, extract, or of any other solid, proportional to the density of the solution. By bringing the liquid in the gravity-bottle to the standard temperature, no correction on this account is needed.

SACCHARIC ACID. An uncrystallizable acid product, formed along with oxalic acid during the action of nitric acid on sugar.

SA'CCHAROID. A texture resembling that of loaf sugar; as saccharoid carbonate of lime. &c.

SACCHOLACTIC ACID. An acid obtained by digesting sugar of milk in nitric acid. It is identical with that obtained from gum, and termed *mucous acid*.

SAFETY LAMP. A lamp invented by Sir H. Davy, which is so constructed as to burn without any danger in an explosive atmosphere. Flame may be considered as vapor or aeriform matter in a state of intense ignition; the temperature, therefore, of flame is always very high. It is, however, independent of its luminosity; for some of the dimmest flames, those of pure hydrogen gas, and of alcohol, for instance, are those which are hottest; and that this is so may be shown by projecting into them finely-powdered substances, such as magnesia or lamp-black, or by holding in them fine platinum wire, when the intensity of their temperature is rendered evident by those substances becoming white hot. And whenever flames emit much light they derive that property from the presence of finely divided matter diffused through them: thus, the intense brilliancy of the flame of phosphorus appears to depend upon the particles of incombustible phosphoric acid diffused through it; and the bright light emitted by a gas flame depends upon finely-divided charcoal, which is ignited by the gas and at the same time burned. The correctness of this *theory of flame* is shown by the circumstance of its being extinguished by cooling; and this is best effected by causing it to pass through a piece of fine wire gauze, which, when held horizontally in the midst of the flame, extinguishes its upper part: the inflammable vapor or gas, and the soot or carbon, pass through, but in passing are so far cooled as to be extinguished; they may, however, be rekindled by applying a flame above the wire gauze. That the wire gauze merely acts by its cooling power, is shown by the flame passing through it when it acquires a white heat, or when its meshes are not fine enough to exert a due cooling power; it is also found that very hot flames, such as that of hydrogen, will pass through tissues which are impervious to flames of a lower temperature, such as that of a common candle or a gas flame. The application of these principles to the construction of the safety lamp is as follows: The flame of a small oil lamp is surrounded by a cylinder of wire gauze, doubled where likely to become hottest, and protected by the stout wire frame, and burns within it, the air having free ingress and egress. When it is immersed in an explosive atmosphere, such as that of a coal mine infested by fire-damp, the inflammable gas enters without and burns *in* the cage; but, in consequence of the cooling power of the wire gauze, no flame can pass *outwards* so as to ignite the surrounding atmosphere: the miner, therefore, is warned of his danger by the appearance of his lamp. As long as the external atmosphere is safe, the lamp burns as usual; but upon the approach of the fire-damp the flame is more or less enlarged; and in the most explosive condition of the surrounding air the cylinder appears filled with a blue lambent flame, which flickers, within it, the wick of the lamp appearing for the time extinguished. It is, however, rekindled as the air becomes more pure; or should the fire-damp greatly predominate, it may be entirely extinguished. Before this happens, however, the miner is duly apprised of his danger, and has time to retreat. (SEE LAMP OF DAVY.)

SAFETY VALVE. (*See* STEAM ENGINE and VALVE.)

SAFFLOWER, or CARTHAMUS.—Watery menstrua take up only the yellow, and leave the red color to be afterwards be extracted by alcohol, or by a weak solution of alkali. This, after the yellow matter has been extracted by water, gives a tincture to ley, from which, on standing at rest for some time, a deep red fecula subsides, called *carthamine*. This pigment impregnates alcohol with a beautiful red tincture, but communicates no color to water. (*See* ROUGE.)

Carthamus is used for dyeing silk of a poppy, cherry, rose, or bright orange-red. After the yellow matter is extracted, the cakes are put into a deal trough, and sprinkled at different times with soda, well powdered and sifted, in the proportion of six pounds to a hundred, mixing the alkali with carbonic acid. The carthamus is then put on a cloth, in a trough with a grated bottom, placed on a larger trough, and cold water poured on. And this is repeated, with the addition of little more alkali, till the red is exhausted. Lemon-juice is then poured into the bath, till it is turned of a fine cherry color, and, after it is well stirred, the silk is immersed in it. The silk is wrung, drained, and passed through fresh baths, washing and drying after every operation; when it is brightened in hot water and lemon-juice. For a poppy or fire color, a slight annotto ground is first given; but the silk should not be alumed. For a pale carnation, a little soap should be put into the bath.

SAFFRON. The prepared stigmata of the *Crocus sativus*. The stigmata of this purple crocus are of a deep orange color, and when in quantity have a peculiar and very characteristic odor; they are used in medicine, chiefly as a rich yellow or orange coloring matter. Saffron is now chiefly imported from the south of Europe, especially Spain. Saffron is often largely adulterated with the petals of other plants, especially with those of the marigold.

It contains a yellow matter called *polychroite*, because a small quantity of it is capable of coloring a great body of water. This is obtained by evaporating the watery infusion of saffron to the consistence of an extract, digesting the extract with alcohol, and concentrating the alcoholic solution. The polychroite remains in the form of a brilliant mass, of a reddish-yellow color, transparent, and of the consistence of honey. It has the agreeable smell, with the bitter pungent taste, of saffron. It is very soluble in water; and if it be stove-dried, it deliquesces speedily in the air. According to M. Henry *pere*, polychroite consists of eighty parts of coloring matter, combined with 20 parts of a volatile oil, which cannot be separated by distillation till the coloring matter has been combined with an alkali. By mixing one part of shred saffron with eight parts of saturated brine, and one half of caustic ley, and distilling the mixture, the oil comes over into the receiver, and leaves the coloring matter in the retort, which may be precipitated from the alkaline solution by an acid. The pure coloring matter, when dried, is of a scarlet hue, and then readily dissolved in alcohol, as also in the fat and volatile oils, but sparingly in water. Light blanches the reddish-yellow of saffron, even when it is contained in a full vial well corked. Polychroite, when combined with fat oil, and subjected to dry distillation, affords ammonia, which shows that azote is one of its constituents. Sulphuric acid colors the solution of polychroite indigo blue, with a lilach cast; nitric acid turns it green of various shades, according to the state of dilution. Protochloride (muriate) of tin produces a reddish precipitate.

Saffron is employed as a seasoning in French cookery. It is also used to tinge confectionary articles, liqueurs, and varnishes; but rarely as a pigment.

SAGO, is prepared from the pith of the Cycas Circinalis, and its granulated form arises from its being passed, while moist, through a sieve.

SAL AMMONIAC. Muriate of ammonia; hydrochlorate of ammonia. A compound of 17 of ammonia and 37 hydrochloric acid. Its name is derived from the Temple of Ammon, in Egypt, where it was originally made by burning camels' dung. (*See* AMMONIA.)

Sal ammoniac exists ready formed in several animal products. The dung and urine of camels contain a sufficient quantity to have rendered its extraction from them a profitable Egyptian art in former times, in order to supply Europe with the article. In that part of Africa, fuel being very scarce, recourse is had to the dung of these animals, which is dried for that purpose, by plastering it upon the walls. When this is afterwards burned in a peculiar kind of a furnace, it exhales a thick smoke, replete with sal ammoniac in vapor; the soot of course contains a portion of that salt, condensed along with other products of combustion. In every part of Egypt, but especially in the Delta, peasants are seen driving asses loaded with bags of that soot, on their way to the sal ammoniac works. There it is extracted in the following manner. Glass globes coated with loam are filled with the soot pressed down by wooden rammers, a space of only two or three inches being left vacant, near their mouths. These globes are set in round orifices formed in the ridge of a long vault, or large horizontal furnace flue. Heat is gradually applied by a fire of dry camels' dung, and it is eventually increased till the globes become obscurely red. As the muriate of ammonia is volatile at a temperature much below ignition, it rises out of the soot in vapor, and gets condensed into a cake upon the inner surface of the top of the globe. A considerable portion, however, escapes into the air; and another portion concretes in the mouth, which must be cleared from time to time by an iron rod. Towards the end, the obstruction becomes very troublesome, and must be most carefully attended to and obviated, otherwise the globes would explode by the uncondensed vapors. In all cases, when the subliming process approaches to a conclusion, the globes crack or split; and when they come to be removed, after the heat has subsided, they usually fall to pieces. The upper portion of the mass is separated because to it the white salt adheres; and on detaching the pieces of glass with a hatchet, it is ready for the market. At the bottom of each balloon a nucleus of salt remains, surrounded with fixed pulverulent matter. This is reserved, and after being bruised, is put in along with the charge of soot in a fresh operation.

The sal ammoniac obtained by this process is dull, spongy, and of a gravish hue: but nothing better was for a long period known in commerce. The most ordinary process for converting the ammoniacal liquor of the gas-works into sal ammoniac, is to saturate it with sulphuric acid, and to decompose the sulphate, thus formed, by the processes above described. But muriatic acid will be preferred, where it is as cheap as sulphuric of equivalent saturating power; because a tolerably pure sal ammoniac is thereby directly obtained. As the coal-gas liquor contains a good deal of sulphureted hydrogen, the saturation of it with acid should be so conducted as to burn the disengaged noxious gases in a chimney. Formerly human urine was very extensively employed, both in this country and in France, in the manufacture of sal ammoniac: but since the general establishment of gas-works, it has been every where abandoned. The process was exceedingly offensive.

The best white sal ammoniac is in spheroidal cakes of about one foot diameter, three or four inches thick in the middle, somewhat thinner at the edges, and is semi-transparent or translucent. Each lump weighs about one quarter of a cwt. As it is easily volatilized by heat, it may be readily examined as to its sophistication with other salts. Sal ammoniac has a certain tenacity, and is flexible under the hammer or pestle. It is principally used in tinning of cast-iron; wrought-iron, copper, brass, and for making the various ammoniacal preparations of pharmacy.

In a chemical factory near Glasgow, 7200 gallons of ammoniacal liquor, obtained weekly from the gas-works, are treated as follows :—The liquor is first rectified by distillation from a wagon-shaped wrought-iron boiler, into a square cistern of iron lined with lead. 4500 lbs. of sulphuric acid, of specific gravity 1·825, are then slowly added to the somewhat concentrated distilled water of ammonia. The produce is 2400 gallons of sulphate of ammonia, slightly acidulous, of specific gravity 1·150, being of such strength as to deposit few crystals upon the sides of the lead-lined iron tank in which the saline combination is made. It is decomposed by common salt.

From the 7200 gallons of the first crude liquor, 900 gallons of tar are got by subsidence, and 200 gallons of petroleum are skimmed off the surface. The tar is converted, by a moderate boiling in iron pans, into good pitch.

SALEP, or SALOUP, is the name of the dried tuberous roots of the *Orchis*, imported from Persia and Asia Minor, which are the product of a great many species of the plant, but especially of the *Orchis mascula*. Salep occurs in commerce in small oval grains, of a whitish-yellow color, at times semi-transparent, of a horny aspect, very hard, with a faint peculiar smell, and a taste like that of gum tragacanth, but slightly saline. These are composed almost entirely of starchy matter, well adapted for making a thick pap with water or milk, and are hence in great repute in the Levant, as restorers of the animal forces. Their aphrodisiacal properties are apocryphal. If the largest roots of the *Orchis mascula* of our own country were cleaned, scraped, steeped for a short time in hot, and then for a few minutes in boiling water, to extract their rank flavor, afterward, suspended upon strings to dry in the air they would afford as nourishing and palatable an article as the Turkey saloup, and at a vastly lower price.

SALICINE, is a febrifuge substance, which may be obtained in white pearly crystals from the bark of the white willow (*Salix alba*), of the aspen tree (*Salix helix*), as also of some other willows, and some poplars. It has a very bitter taste.

SAL PRUNELLA, is fused nitre cast into cakes or balls.

SAL VOLATILE, is sesquicarbonate of ammonia.

SALT, EPSOM, is sulphate of magnesia.

SALT, MICROCOSMIC, is the triple phosphate of soda and ammonia.

SALT OF AMBER, is succinic acid.

SALT OF LEMONS, is citric acid.

SALT OF SATURN is acetate of lead.

SALT OF SODA, is carbonate of soda.

SALT OF SORREL, is bi-oxalate of potassa.

SALT OF TARTAR, is carbonate of potassa.

SALT OF VITRIOL, is sulphate of zinc.

SALT PERLATE, is phosphate of soda.

SALTPETRE, is nitre, or nitrate of potassa

SALT, SEDATIVE, is boracic acid.

SALT. This term, though in ordinary language limited to common salt, or sea salt, is applied in chemistry to all combinations of acids with alkaline or salifiable bases. The term has also been extended to certain binary combinations of chlorine, iodine, bromine, and fluorine with the metals ; and these have been called *haloid salts* (from *αλς, sea salt, and ειδος, form*), inasmuch as modern chemistry has taught us that sea salt belongs to this class. Certain definite combinations of sulphurets with each other have of late been called *sulphur salts* ; but the former appellation of *double sulphurets* is, perhaps, more properly applicable to such compounds.

Sea salt is a compound of 1 equivalent of sodium = 24, and 1 of chlorine = 36 ; its equivalent, therefore, is (24 + 36) = 60 : and it is a chloride of soda.

The nomenclature of salts has reference to the acids which they contain ; *sulphates, nitrates, carbonates*, &c., implying salts of the sulphuric, nitric, and carbonic acids. The termination *ate* implies the maximum of oxygen in the acids, and *ite* the minimum: thus the salts of sulphurous and nitrous acids are called *sulphites* and *nitrites*. When salts contain 1 equivalent of acid and 1 of base, they are called *neutral salts*; where 1 equivalent of acid is combined with 2 of base, they are termed *basic salts*, *subsalts* or *disalts*; and where there are 2 equivalents of acid and 1 of base, the salt is a *supersalt* or *bisalt*. Thus, the terms *subacetate* and *diacetate of lead* are synonymous; so are *supercarbonate* and *bicarbonate of potash*. Many salts are *hydrous*; that is, they contain a definite proportion of water of crystallization; others are destitute of water, and are dry or *anhydrous salts*. Some salts attract moisture when exposed to air, and are said to be *deliquese*; others suffer their water to escape and become opaque, or pulverulent: these are called *efflorescent salts*.

Salt is, next to bread, the most important necessary of life. It is one of the most important British minerals, and is procured in great quantities, both from fossil beds and brine springs, in Cheshire and Worcestershire. Previously to the discovery of the fossil beds during the 16th century, and subsequently, a good deal of salt continued to be made by the evaporation of sea water in salt pans, at Lymington and many other places; but the works at these places are now all but abandoned; while not only has the quality of the article in question become greatly improved, but, instead of being imported as formerly, it is now largely exported. The consumption of Great Britain only, exclusive of Ireland, amounts to about 180,000 tons; and the foreign exports to about 300,000 tons per year, of which the United States, Canada, the Low Countries, Russia, Prussia, and Denmark are the chief consumers.

The geological position of rock-salt is between the coal formation and the lias. The great rock-salt formation of England occurs within the *red marl*, or new red sandstone, the *bunter-sandstein* of the Germans, so called, because its colors vary from red to salmon and chocolate. This mineral stratum frequently presents streaks of light blue, verdigris, buff, or cream color; and is chiefly remarkable for containing considerable masses or beds of gypsum. At Northwich, in the vale of Weaver, the rock salt consists of two beds, together not less than 60 feet thick, which are supposed to constitute large insulated masses, about a mile and a half long, and nearly 1300 yards broad. There are other deposits of rock salt in the same valley, but of inferior importance. The uppermost bed occurs at 75 feet beneath the surface, and is covered with many layers of indurated red, blue, and brown clay, interstratified more or less with sulphate of lime, and interspersed with argillaceous marl. The second bed of rock-salt lies 31½ feet below the first, being separated from it by layers of indurated clay, with veins of rock-salt running through them. The lowest bed of salt was excavated to a depth of 110 feet, several years ago.

The beds or masses of rock-salt are occasionally so thick, that they have not been yet bored through, though mined for many centuries. This is the case with the immense mass of Wieliczka, and the lower bed at Northwich. But in ordinary cases, this thickness varies from an inch or two to 12 or 15 yards. When the strata are thin, they are usually numerous; but the beds, layers, or masses never exhibit throughout a great extent any more than an illusory appearance of parallelism; for when they are explored at several points, enlargements are observed, and such diminutions as cause the salt to disappear sometimes altogether. This mineral is not deposited, therefore, in a geological stratum, but rather in lenticular masses, of very variable extent and thickness, placed alongside of each other at unequal distances, and interposed between the courses of other formations.

Sometimes the rock salt is disseminated in small masses or little veins among the calcareous and argillaceous marls which accompany or overlie the greater deposits. Bitumen, in small particles, hardly visible, but distinguishable by the smell, occurs in all the minerals of the saliferous system.

It has been remarked, that the plants which grow generally on the sea shores, such as the *Triglochinum maritimum*, the *Salicornia*, the *Salsola kali*, the *Aster trifolium*, or farewell to summer, the *Glaux maritima*, &c., occur also in the neighborhood of salt mines and salt springs, even of those which are most deeply buried beneath the surface.

The interior of rock-salt mines, after digging through the strata of clay marl, &c. is extremely dry; so that the dust produced in the workings becomes an annoyance to the miners, though in other respects the excavations are not at all insalubrious.

Salt springs occur nearly in the same circumstances, and in the same geological formation as the salt-rock. It has been noticed that salt springs issue, in general, from the upper portion of the saliferous strata, principally from the saline clay marls. Cases however occur, where the salt springs are not accompanied by rock-salt, and where the whole saline matter is derived from the marls themselves, which thus constitute the only saliferous beds.

The salt used in the United States, is derived here by importation from Liverpool, or from Turks Island, or obtained from the salines of Onondaga, the waters of which are evaporated to dryness. That of Turks Island is chiefly produced by solar evaporation. In Key West, Florida, the manufacture of salt by solar evaporation is carried on on a small scale, that is from 30 to 40 thousand bushels yearly. This salt is of a superior quality for packing meat. The manufacture commenced in 1845. The salt made in the State of New York, is from the salines of Onondaga, the waters of which furnish abundance of salt, as much as from 16 to 25 ozs. to the gallon of water. The State imposes a tax of 12½ cents per bushel on all salt made. Besides muriate of soda the waters contain chloride, calcium, sulphates of lime and magnesia, and oxide of iron. Some years back there were annually produced half a million bushels of salt per year, the price 25 cents per bushel. The salt is obtained by evaporating the brine down to the point of crystallization and separating the impurities.

The State Superintendent of the Salines of Onondaga, reports as follows: "We have manufactured this year (1849) very nearly five million bushels of salt already, and shall exceed that figure somewhat at the close of the year, say 300,000 bushels over last year. (The bushel is reckoned at 26 lbs.) In regard to the consumption of fuel, I cannot say much that will be new to you. No improvement has been made, perhaps, since you were here."

The importance of these Salines may be inferred from the fact, that in the year 1836 the whole import of salt into the ports of the United States amounted to 5,088,668 bushels, of 56 lbs each, being but a trifle more than this year's production of the Salines of Onondaga.

With regard to the use of Anthracite coal, as fuel for making salt, the experiment is said not to have been successful, and that the gentleman who made the trial has since substituted wood for coal. Heretofore one cord of wood was used in making forty bushels of salt. At that rate, 125,000 cords of wood are required for the evaporation of brine for 5,000,000 bushels of salt. About forty gallons of brine make a bushel of salt, therefore requiring two hundred millions of gallons of brine to be raised from the wells, to produce the quantity. By the Salometer, the brine tests about 74°—0 being the mark for fresh water, and 100° for brine of full saturation.

"From very minute and extensive examinations of the Salines of Onondaga, and from my own experience in the evaporation of fluids by heat, my opinion is clear, that 25,000 cords of wood may be made to do the work heretofore performed by 125,000 cords."

SALTPETRE, is a natural compound of potash and nitric acid. It abounds in soils where animal substances and lime are in contact, and these being lixiviated, decanted, and evaporated to dryness, crystals of saltpetre are formed. Sometimes they are redissolved, and evaporated a second time.

The chief of the saltpetre used in this country comes from the East Indies, where at certain seasons of the year, it is found deposited on the surface of the soil, and though swept off once or twice a week, it is as often renewed. At Apulia, near Naples, there is a bed containing 40 per cent.; and in Switzerland the farmers extract it in abundance from the earth, under the stalls of their cattle; for the urine of cattle contains potash in abundance. In Spain there is enough to supply all Europe.

It appears, in every case, to be a consolidation of the nitrogen of the atmosphere, which consolidates, in this way, just as oxygen consolidates in the production of rust and oxides of all kinds. Thus considered, the consolidation of one promotes the consolidation of the other, since they are always present in the air as 1 oxygen and 3·5 nitrogen.

Saltpetre-earth absorbs a little moisture at night, and appears like a black foot-dust at the bottom of old walls, or on the streets of populous or old villages.

It does not differ in appearance from that which yields salt or soda; and indeed, one village, or one street, frequently contains the three salts.

The most profitable way of preparing it is, to evaporate it in shallow basins of mortar. The earth is swept up every other day and contains about one-fifth of crude saltpetre. After the saltpetre is extracted, the earth is heaped up till the rains are over, and then spread out, and in a year or two it yields again.

About two gallons of saltpetre-earth is collected at the foot of each yard of wall. The saltpetre gained from black cotton ground contains more common salt than that from common earth. The pans of mortar are filled about four inches deep, about half is evaporated in four or six days, and the saltpetre begins to crystallize. The first day's product is the purest; the second day's contains about half common salt: the third day's contains scarcely a quarter of saltpetre.

Saltpetre is refined by boiling; adding soap, milk, eggs, and twigs of euphorbia tirucalli: and single refined saltpetre still contains about a quarter of common salt. Bengal saltpetre is browner than that of the coast.

If saltpetre is kept or prepared in any apartment, it is difficult, in India, to prevent the destruction of the walls, by the continual production of the salt.

Calcareous earths, impregnated with saltpetre, are found in caverns in limestone, in various places. The saltpetre earth of Georgia, contains both the nitrate of potash and that of lime; but the latter is changed into saltpetre, by adding wood-ashes; one bushel of earth yields from three to ten pounds of saltpetre. Kentucky saltpetre-earth is similar; it is washed, and the ley passed through wood-ashes, when a bushel yields from one to two pounds of saltpetre.

Similar earths are found at Molfetta, Naples, Hungary, and various places.

Kentucky rock-ore is a sand-stone, which, when broken to fragments, and thrown into boiling-water, soon falls into sand, and the liquor strained from it yields, by crystallization, from ten to twenty pounds of nitre from each bushel of stone. This nitre contains little or no nitrate of lime, and is considered better for gunpowder than that obtained from Kentucky nitre-earth. Masses of saltpetre, of several pounds weight, are sometimes found in the fissures of this sand-stone, accompanied by masses of a black bituminous substance. Similar sand-stones are found in South Africa.

The saltpetre formerly used in England was extracted from the mortar of old buildings, as it still is in France and Prussia. The mark, by which saltpetre-workers know good mortar for their purpose is, that it tastes acrid and salt, when applied to the tongue: but to this it may be also added, that it ought to be of a grayish colour, and such as, when powdered and sprinkled upon burning charcoal, yields sparks; and, the more sparks it gives, the better it is for the purpose. Another characteristic is, that these well-impregnated mortars have a certain unctuosity or fattiness to the touch, which other kinds have not.

The best of all kinds of mortar, for saltpetre work, is such as is had from the ruins of old buildings in a low situation, and out of the way of much sunshine, where there has been no great quantity of fire kept, and especially such as has served for the mortar of the walls of stables. In Prussia, the rubbish of old buildings is built up in thin long walls, sheltered from the weather by straw coverings, and sprinkled with urine of all kinds, for the purpose of generating this salt.

A clear dry frosty air is particularly favorable to the production of saltpetre, and it disappears in snow-storms.

Napier detected impurities in nitre, by dropping a strong solution of sugar of lead into a phial of distilled water, saturated with saltpetre; if it retained any considerable portion of marine-salt or magnesia, it assumed a turbid milky appearance. The best is Russian; yet the manufacturers seldom refine their nitre more than twice; and it has been found that their saltpetre contains a considerable portion of marine-salt and magnesia. There is reason to believe, that powder, made with saltpetre oftener than four times refined, is of inferior strength.

The goodness of saltpetre is measured by the angle at which light is refracted in passing through it. As the angle is less, the quality is better. This angle varies very considerably. An angle of 5° is called par, and, the variations from it are made up by increasing or diminishing, not the price, but the quantity; for every degree by which its angle of refraction exceeds 5, 1 per cent. in weight is allowed, and the contrary.

SAND is the name given to any mineral substance in a hard granular or pulverulent form, whether strewed upon the surface of the ground, found in strata at a certain depth, forming the beds of rivers, or the shores of the sea. The silicious sands seem to be either original crystalline formations, like the sand of Neuilly, in six-sided prisms, terminated by two six-sided pyramids, or the *debris* of granitic, schistose, quartzose, or other primitive crystalline rocks, and are abundantly distributed over the globe; as in the immense plains known under the names of downs, deserts, *steppes*, *landes*, *&c.*, which, in Africa, Asia, Europe, and America, are entirely covered with loose sterile sand. Valuable metallic ores, those of gold, platinum, tin, copper, iron, titanium, often occur in the form of sand, or mixed with that earthy substance. Pure silicious sands are very valuable for the manufacture of glass, for making mortars, filters, ameliorating dense clay soils, and many other purposes. Its chief uses are in compositions for pottery and glass, and some sands are more and some less fusible, according to the various stones from which they may have originated. The size of the particles is of importance in these works. It is the wearing down of rocks by attrition, during the sub-marine state, or the advance and retreat of the ocean.

Sand drifts, or floods, are arrested by planting marum, or sea-bent, or the arundo arenania, and other plants, that take root in sand.

Sandstone is, in most cases, composed chiefly of fine grains of quartz, united by a cement, which is nearly or quite invisible. The cement is variable, and may be calcareous or marly, argillaceous, or argillo-ferruginous, or even silicious. When silicious, sandstone resembles quartz. Some varieties are so hard as to give fire with steel, while others are friable, and may be reduced to powder by the fingers. Some have a slaty structure, arising from scattered and insulated plates of mica, and are often called sandstone slate. Some sandstones contain grains of feldspar, flint, and silicious slate or plates of mica. The mica is in considerable quantities in those friable sandstones which accompany coal. Some are so ferruginous as to form a valuable ore of iron, containing either an oxide or the carbonate of iron. Red sandstone is sometimes connected with coal. In the older formation it sometimes contains metallic substances disseminated through the mass, or in beds or veins. Various organic remains occur in sandstone, among which are reeds, impressions of leaves, trunks of trees, and shells, both fluviatile and marine. In some of its varieties it is often known by the name of freestone, and is employed as a building-stone. In most cases, it may be cut equally well in all directions; but some varieties naturally divide into prismatic masses. Some compounds are used as mill-stones. When porous, it is employed for filtering water. Some are even used for whetstones.

SANDAL or RED SAUNDERS WOOD is the wood of the *Pterocapus santalinus*, a tree which grows in Ceylon, and on the coast of Coromandel. The old wood is preferred by dyers. Its coloring matter is of a resinous nature; and is, therefore, quite soluble in alcohol, essential oils, and alkaline leys; but sparingly in boiling water, and hardly if at all in cold water. The coloring matter which is obtained by evaporating the alcholic infusion to dryness, has been called *santaline*; it is a red resin, which is fusible at 212° F. It may also be obtained by digesting the rasped sandal wood in water of ammonia, and afterwards saturating the ammonia with an acid. The *santaline* falls, and the supernatant liquor, which is yellow by transmitted, appears blue by reflected light. Its spirituous solution affords a fine purple precipitate with the protochloride of tin, and a violet one with the salts of lead. Santaline is very soluble in acetic acid, and the solution forms permanent stains upon the skin.

SANDARACH, is a peculiar resinous substance, the product of the *Thuya articulata*, a small tree of the coniferous family, which grows in the northern parts of Africa, especially round Mount Atlas.

The resin comes to us in pale yellow, transparent, brittle, small tears, of a spherical or cylindrical shape. It has a faint aromatic smell, does not soften, but breaks between the teeth, fuses readily with heat and has a specific gravity of from 1·05 to 1·09. It contains three different resins; one soluble in spirit of wine, somewhat resembling *pinic acid* (*see* TURPENTINE); one not soluble in that menstruum; and a third, soluble only in alcohol of 90 per cent. It is used as pounce-powder, for strewing over paper erasures, as incense, and in varnishes.

SAP GREEN. The inspissated juice of the berries of the buckthorn.

SAPAN WOOD is a species of the *Cæsalpinia* genus, to which Brazil wood belongs. It is so called by the French, because it comes to them from Japan, which they corruptly pronounce Sapan. As all the species of this tree are natives of the East Indies or the New World, one would imagine that they could not have been used as dyestuffs in Europe before the 16th century.

Yet the author of the article "Brazil," in Rees' Cyclopædia, and Mr. Southey, in his History of Brazil, say that *Brazil* wood is mentioned nearly one hundred years before the discoveries of Columbus and Vasco de Gama, by Chaucer, who died in 1400; that it was known many ages before this time; and that it gave the name to the country, instead of the country giving the name to the wood, as is stated by Berthollet and other writers on dyeing. The *Cæsalpinia sappan*, being a native of the Coromandel coast, may *possibly* have been transported along with other Malabar merchandise to the Mediterranean marts in the middle ages.

SARD. (*See* LAPIDARY.)

SARCOCOLL, a gum, sold in globules, smelling like aniseed. It yields oxalic acid, and a variety of liquorice; in nitric acid it is converted into tannin.

SASH. In Architecture, a piece of framing for holding the squares of glass in a window. It is of two sorts—viz., that called the French sash, which is hung like a door to the sash-frame; and that in which it moves vertically from being balanced by a weight on each side, to which it is attached by lines running over pulleys at the top of the sash-frame. When in a window where both the upper and lower sashes are moveable, the sashes are said to be double hung, and single hung when only one of them moves.

SASH SUPPORTER. A substitute for weights and pullies in supporting window sashes has been invented and patented by Mr. J. A. Pease, of Philadelphia. The cheapness at which it can be afforded and the manner and ease with which it works, render it a valuable invention; it is very simple in its construction and admirably answers the purpose for which it is intended. It consists of a metal box with a shaft or roller covered in the centre with India rubber or other elastic substance; the ends of the shaft play in the journals of the box, which is placed in the frame of the window. The bearing of the elastic roller upon the sash holds it in any desired position, and at the same time allows the sash to be moved with ease; it is not liable to get out of order, and the roller being elastic does not wear the sash, it also keeps the sash from being shaken with the wind. We have no doubt but that it will come into general use, as the saving by its use over the weights and pullies is from one to two dollars per window.

SATIN; a soft closely-woven silk, with a glossy surface. In the manufacture of other silken stuffs, each half of the warp is raised alternately; but, in weaving satin, the workman only raises the fifth or the eighth part of the warp; thus the woof is hidden beneath the warp, which, presenting an even, close, and smooth surface, is capable of reflecting the rays of light. In this way satin acquires that lustre and brilliancy which distinguishes it from most other kinds of silks.

SAWS, are wedges to tear their way through an obstacle. They are reciprocating or circular. The former are well known as hand-saws, or reciprocating ones, such as are seen in sawpits. The circular, as better adapted to power, and more precise and rapid in their action, are becoming general. They were invented in Holland, about 1780, and are a great acquisition. The machine which turns the saw draws the piece to the work, which is so accurate that an inch thick of certain woods may be divided into twenty uniform sheets, allowing for waste.

SCAGLIOLA. In Architecture, a composition, sometimes called also *Mischia*, from the mixture of colors employed in it, being made to imitate marble. The Florentines claim the invention of this art, but it had been practised in Lombardy previous to its introduction at Florence. Lanza says that it was invented by Guido Sassi, who died in 1649, at the age of 65, at Carpis, in the state of Modena, and that he commenced by executing cornices and other members of architecture which had all the appearance of the finest marbles; whereas its introduction at Florence was not till the middle of the 18th century. Scagliola is composed of gypsum or sulphate of lime, calcined and reduced to a fine powder, with the addition of which to water a fine paste is made. When columns are made with this composition, a frame or cradle is first formed, which is lathed round and coated with lime and hair, raised up in some parts with small projections. On this, when dry, is laid a composition consisting of pure gypsum, calcined and passed through a sieve, and, as wanted, mixed with glue or isinglass; it is floated with wooden moulds of the proper form, during which operation the colors, by which the imitation is obtained, are put on. When this is set the work is smoothed with pumice-stone with one hand of the workman, while the other is employed in washing it with a sponge and water. It is then polished with tripoli, charcoal, and a piece of fine linen, and afterwards with a piece of felt dipped in oil of tripoli, and finished off with pure oil laid on with cotton wool.

SCALE. In mensuration, a line or rule of a definite length, divided into a given number of equal parts, and used for the purpose of measuring other linear magnitudes. It becomes a *standard scale* when all its divisions have been examined and compared with some *standard measure*. The scales of thermometers are graduated from some arbitrary point or zero (as that which indicates the temperature of freezing water), from which the heat is counted upwards or downwards in degrees, which are also arbitrary.

The term *scale* is also applied to a mathematical instrument, consisting of an assemblage of lines and figures engraved on a plane rule, by means of which certain proportional quantities or arithmetical results are obtained by inspection. Of these the principal are the *plane scale*, the *diagonal scale*, *Gunter's scale*, &c.

SCALES, are measures of the downward tendency, centripetal force, or weight of bodies. A body is put in one scale, whose weight is known, and the arms being truly equal, a body of unknown weight balances the known weight. When well made, they are true to the 50000th of the body weighed; but the friction of large scales renders it ineligible to weigh ounces or grains in them; the friction on a hundred weight is the third of an ounce. (*See* Balance.)

SCANTLING. In architecture, the measures of breadth and thickness of a piece of timber or other material. It is also the name of a piece of timber when under five inches square.

Scantling. In naval architecture, the scale or dimensions of breadth and thickness of the timbers. Thus two ships of different sizes may have the same scantling.

SCARLET DYE. M. Robiquet has given the following prescription for making a *printing scarlet*, for well-whitened woollen cloth.

Boil a pound of pulverized cochineal in four pints of water down to two pints, and pass the decoction through a sieve. Repeat the boiling three times upon the residuum, mix the eight pints of decoction, thicken them properly with two pounds of starch, and boil into a paste. Let it cool down to 104° F., then add four ounces of the subjoined solution of tin, and two ounces of ordinary salt of tin (muriate). When a ponceau red is wanted, two ounces of pounded curcuma (turmeric) should be added.

The solution of tin above prescribed, is made by taking—one ounce of nitric acid, of specific gravity 36° B, = 1·33; one ounce of sal ammoniac; four ounces of grain tin. The tin is to be divided into eight portions, and one of them is to be put into the acid mixture every quarter of an hour.

A solution of chlorate of potassa (chloride ?) is said to beautify scarlet cloth in a remarkable manner.

Bancroft proposed to supplant the nitro-muriatic acid, by a mixture of sulphuric and muriatic acids, for dissolving tin; but I do not find that he succeeded in persuading scarlet-dyers to adopt his plans. In fact, the proper base may be, perhaps, a mixture of the protoxyde and peroxyde of tin; and this cannot be obtained by acting upon the metal with the murio-sulphuric acid. He also prescribed the extensive use of the quercitron yellow to change the natural crimson of the cochineal into scarlet, thereby economizing the quantity of this expensive dye-stuff.

SCHEELE'S GREEN is a pulverulent arsenite of copper, which may be prepared as follows:—Form, first, an arsenite of potassa, by adding gradually 11 ounces of arsenious acid to 2 pounds of carbonate of potassa, dissolved in 10 pounds of boiling water; next, dissolve 2 pounds of crystallized sulphate of copper in 30 pounds of water; filter each solution, then pour the first progressively into the second, as long as it produces a rich grass-green precipitate. This being thrown upon a filter-cloth, and edulcorated with warm water, will afford 1 pound 6 ounces of this beautiful pigment. It consists of, oxide of copper 28·51, and of arsenious acid 71·46. This green is applied by an analogous double decomposition of cloth. (*See* Calico-printing.)

SCHWEINFURTH GREEN is a more beautiful and velvety pigment than the preceding, which was discovered in 1814, and remained for many years a profitable secret. M. Liebig having made its composition known, in 1822, it has been since prepared in a great many color-works. Braconnot published, about the same time, another process for manufacturing the same pigment. Its preparation is very simple; but its formation is accompanied with some interesting circumstances. On mixing equal parts of acetate of copper and arsenious acid, each in a boiling concentrated solution, a bulky olive-green precipitate is immediately produced; while much acetic acid is set free. The powder thus obtained, appears to be a compound of arsenious acid and oxide of copper, in a peculiar state; since when decomposed by sulphuric acid, no acetic odor is exhaled. Its color is not changed by drying, by exposure to air, or by being heated in water. But, if it be boiled in the acidulous liquor from which it was precipitated, it soon changes its color, as well as its state of aggregation, and forms a new deposit in the form of a dense granular beautiful green powder. As fine a color is produced by ebullition during five or six minutes, as is obtained at the end of several hours by mixing the two boiling solutions, and allowing the whole to cool together. In the latter case, the precipitate, which is slight and flocky at first, becomes denser by degrees; it next betrays green spots, which progressively increase, till the mass grows altogether of a crystalline constitution, and of a still more beautiful tint than if formed by ebullition.

SCISSEL. The clippings of various metals produced in several mechanical operations concerned in their manufacture. The slips or plates of metal out of which circular blanks have been cut for the purpose of coinage are called scissel at the mint.

SCOURING AND CLEANSING. The general principle of cleansing all spots, consists in applying to them a substance which shall have a stronger affinity for the matter composing them, than this has for the cloth, and which shall render them soluble in some liquid menstruum, such as spirits, naptha, oil of turpentine, &c. (*See* BLEACHING.)

Alkalies would seem to be proper in this point of view, as they are the most powerful solvents of grease; but they act too strongly upon silk and wool, as well as change too powerfully the colors of dyed-stuffs, to be safely applicable in removing stains. The substances for this purpose are—1. Soap. 2. Chalk, fuller's earth, soap-stone or steatite (called in this country French chalk). These should be merely diffused through a little water into a thin paste, spread upon the stain and allowed to dry. The spot requires now to be merely brushed. 3. Ox-gall and yolk of egg have the property of dissolving fatty bodies without affecting perceptibly the texture or colors of cloth, and may therefore be employed with advantage. The ox-gall should be purified, to prevent its greenish tint from degrading the brilliancy of dyed-stuffs, or the purity of whites. Thus prepared (*see* GALL), it is the most precious of all substances known for removing these kind of stains. 4. The volatile oil of turpentine will take out only recent stains; for which purpose it ought to be previously purified by distillation over quicklime. Wax, resin, turpentine, pitch, and all resinous bodies in general, form stains of greater or less adhesion, which may be dissolved out by pure alcohol. The juices of fruits, and the colored juices of all vegetables in general, deposit upon clothes marks in their peculiar hues. Stains of wine, mulberries, black currants, morelles, liquors, and weld, yield only to soaping with the hand, followed by fumigation with sulphurous acid; but the latter process is inadmissible with certain colored stuffs. Iron mould or rust stains may be taken out almost instantaneously with a strong solution of oxalic acid. If the stain is recent, cream of tartar will remove it.

Compound Spots.—That mixture of rust of iron and grease called *cambouis* by the French, is an example of this kind, and requires two distinct operations; first, the removal of the grease, and then of the rust, by the means above indicated.

Mud, especially that of cities, is a compound of vegetable remains, and of ferruginous matter in a state of black oxide. Washing with pure water, followed if necessary with soaping, will take away the vegetable juices; and then the iron may be removed with cream of tartar, which itself must, however, be well washed out. Ink stains, when recent, may be taken out by washing, first with pure water, next with soapy water, and lastly with lemon juice; but if old, they must be treated with oxalic acid. Stains occasioned by smoke, or by sauces browned in a frying-pan, may be supposed to consist of a mixture of pitch, black oxide of iron, empyreumatic oil, and some saline matters dissolved in pyroligneous acid. In this case several reagents must be employed to remove the stains. Water and soap dissolve perfectly well the vegetable matters, the salts, the pyroligneous acid, and even the empyreumatic oils in a great measure; the essence of turpentine will remove the rest of the oils and all the pitchy matter; then oxalic acid may be used to discharge the iron. Coffee stains require a washing with water, with a careful soaping, at the temperature of 120° F., followed by sulphuration. The two latter processes may be repeated twice or thrice. Chocolate stains may be removed by the same means, and more easily.

As to those stains which change the color of the stuff, they must be corrected by appropriate chemical reagents or dyes. When black or brown cloth is reddened by an acid, the stain is best counteracted by the application of water of ammonia. If delicate silk colors are injured by soapy or alkaline matters, the stains must be treated with colorless vinegar of moderate force.

SCREW. In mechanics, one of the six mechanical powers, consisting of a spiral ridge or groove, winding round a cylinder, so as to cut every line on the surface parallel to the axis at the same angle. The screw may be formed either on the outside or inside of the cylinder; in the former case, it is called the *exterior* or *male* screw: in the latter, the *interior* or *female* screw. The action of the screw resembles that of the wedge, or inclined plane; but as the cylinder has always a handle attached to it, the screw is in reality a compound of the inclined plane and lever; and if the direction of the power be parallel to the base of the cylinder, and perpendicular to its radius, an equilibrium is produced when the power is to the resistance or pressure as the interval between the adjacent threads is to the circumference described by the point to which the power is applied. Hence the mechanical advantage afforded by the screw is proportional jointly to the fineness of the threads and the smallness of the cylinder relatively to the length of the lever or handle. It is to be observed, however, that by diminishing the distance between the threads, or by diminishing the diameter of the cylinder, we diminish also, in both cases, the strength of the screw; and hence there is obviously a limit to the increase of power. But the action is greatly increased by means of the contrivance called a *double screw*, or, from the name of its inventor, *Hunter's screw*, which consists in the combination of two screws of unequal fineness of thread, one of which works within the other. In this case the power does not depend upon the interval between the threads of either screw, but on the difference between the intervals in the two screws, and may be increased to almost any extent.

The *endless screw* consists of a screw combined with a wheel and axle in such a manner that the threads of the screw work into the teeth fixed on the periphery of the wheel. Suppose the power applied to the handle of the screw, and the weight attached to the axle of the wheel, then there will be equilibrium when the power is to the weight as the distance between the threads multiplied by the radius of the axle is to the length of the lever or handle, multiplied by the radius of the wheel.

The *water screw*, or *screw of Archimedes*, is formed by winding a flexible tube round a cylinder in the form of a screw. If the machine, thus constructed, be placed obliquely, so as to make with the vertical an angle equal to that which the spiral makes with the lines parallel to the axis of the cylinder, there will be in each convolution of the spiral a part parallel to the horizon. If any body, then, be placed within the spiral at this part, it will remain at rest; and if the screw be turned the body will ascend, because the part of the screw behind it becomes more inclined than the part before it, and it is consequently urged forward. This simple but ingenious contrivance is usually employed for the purpose of raising water to a small height, but it may be employed to raise any substance that can pass within the tube; and it is evident that the action may be increased by placing several tubes or spiral channels (for they may be formed of wood or iron) on the same cylinder. The principle has been recently applied to the propelling of steam-vessels.

The *micrometer screw* is a contrivance adapted to astronomical or optical instruments, for the purpose of measuring angles with great exactness. The very great space through which the lever of the screw passes in comparison of that which is described by the cylinder in the direction of its length, renders the screw of immense use in subdividing space into minute parts.

As a mechanical power, the screw has innumerable applications; but is employed with most effect in all cases in which a very great pressure is required to be exerted within a small space and without intermission. Hence it is the power generally used for expressing juices from solid substances, for compressing cotton and other goods into hard dense masses for the convenience of carriage, for coining, stamping, printing, &c.

SCREW-CUTTING. Those who are possessed of a lathe with a slide-rest to it, which is now in very frequent use, may convert the screw of that rest into a pattern screw, whereby to cut original right and left threaded screws of various rakes and diameters, in the following simple manner:—The screw of the slide-rest has generally a square formed at one end of it, to fit a winch or handle upon, in order to turn the screw and urge the turning tool forward. Now it will be necessary to have another square, also formed at the opposite end of the screw, upon which a square socket can be secured by a binding-screw; this socket is united with one of the forks of Hook's universal joint, formed of two such forks, with screws passing through the ends of the forks, having conical points to them, which enter into four holes made around an iron ball or sphere, at equal distances apart; the two forks being thus affixed to the ball, at right angles to each other, and as usual in forming this kind of universal joint. The stem of this second fork is elongated, and has a neck or pivot made near its other end, which works in a cleft pivot-hole, formed in a standard, which is affixed on the top of a cylindrical stem, which can be fitted into the socket of the ordinary lathe-rest, and bound by its screw as usual. Upon the exterior end of the stem, beyond the neck or pivot, toothed wheels or pinions, as the case may require, must be fitted, and bound tight by a screw and nut; and into or upon the nose of the lathe-mandrel, a chuck must be screwed, which can, likewise, have other toothed wheels or pinions affixed upon it, next or adjoining to the mandrel, to work into the first mentioned toothed wheels or pinions. The front end of the chuck must also have a square hole made in it, to receive into it the squared end of the steel cylinder, which is to have the screw cut upon it; and the other end of which cylinder is to be supported by the back centre of the lathe as usual.

A properly-shaped turning-tool is then to be placed and screwed fast in the socket of the slide of the slide-rest, and be brought to act upon the steel cylinder, which is to be cut into the screw in the usual manner of turning; and, by the disparity in the proportions of the toothed wheel-work, the turning tool will be carried along faster or slower, so either as to cut coarser or finer threaded screws than the original one, or a similar one, though of a different diameter, if the toothed wheels be equal. The universal joint here is necessary, to accommodate the change of motion from a right line to any angle less than a right angle. Should left hand threaded screws be required, an intermediate wheel or pinion, to reverse the motion, must be affixed to the standard, and be brought to act in the other wheels or pinions.

The following is a simple and economical method of cutting original screws: You must leave the piece of steel from which you intend to form your tap a little longer than necessary, and having turned it true throughout, at one end turn down, somewhat lower than the rest, a neck or space about half an inch in length; round this space coil a piece of wire, and you will, at once, be in possession of a primary artificial guide, which will regulate the pitch of your intended screw. You have nothing now to do but to make your tracing-tool to the spiral groove formed by the wire, and begin tracing your thread. By this simple method you may obtain, by varying the thickness of your wire, a screw of any required pitch, either right hand or left.

SEALING-WAX. The wax used for sealing letters, legal instruments, &c. The best *red* sealing-wax is made by melting in a very gentle heat 48 parts of shell-lac with 19 of Venice turpentine and 1 of Peruvian balsam; 82 parts of the finest cinnabar, thoroughly levigated, are then stirred in, and the whole well mixed. When it has cooled down, it is either rolled into sticks, or shaped in brass moulds. The best *black* sealing-wax is a mixture of 60 parts of shell-lac and 30 of ivory black; it may be perfumed with a little Peru balsam or styrax. The earliest application of sealing-wax to its present use seems to have been made about the year 1553. The first printed account of it is said by Berzelius to have appeared in 1563. The great seals applied in tin boxes to certain legal documents are made of a mixture of 15 parts of Venice turpentine, 5 of olive oil and 8 of wax melted together, and colored with red lead.

Other varieties of sealing-wax are made thus:—To make red, take of camphor, 4 oz.; Venice turpentine, 2 lbs.; vermilion, 1¼ lb., rectified spirit of wine, 16 oz. Dissolve the camphor, first, in the rectified spirit of wine in a suitable vessel, over a slow fire, taking care that no flame touches the evaporating spirit: then add the shell-lac; and when that has become of an uniform smoothness by a moderate application of heat, add the Venice turpentine, and lastly, the vermilion, which should be passed through a hair-sieve held over the melted mass, in order that it may not get into clots. When the whole is well incorporated it may be formed into sticks.

It is usual to weigh out the soft wax into balls, and roll them on a table into the lengths desired, and then flatten them by pressure. They are polished by being held over a charcoal fire in a chafing-dish, then drawn over a tallow candle and rubbed with soft leather.

Black wax. Instead of vermilion, employ *lampblack*. *Black resin* is also often used in about one-third the quantity of the shell-lac, thus: Take of camphor, 1 oz.; shell-lac, 2½ lbs.; black resin, 1½ lbs.; oil of turpentine 8 oz.; rectified spirit of wine, 8 oz.; lampblack, 4 oz. Dissolve the camphor in the rectified spirit of wine, then add the shell-lac, to which pour the resin previously melted and mixed with the oil of turpentine; using, of course, a moderate heat, and taking care that no flame touches the melting matters.

SECTOR. A mathematical instrument, of considerable use in making diagrams, laying down plans, &c. Its principal advantage consists in the facility with which it gives a graphical determination of proportional quantities; and hence it is called by the French *the compass of proportion.*

The instrument consists of two rulers (generally of brass or ivory), representing the radii of a circular arc, and movable round a joint, the middle of which forms the centre of the circle. From this centre there are drawn on the faces of the rulers various scales; the choice of which, and the order of their arrangement, may be determined by a consideration of the uses for which the instrument is chiefly intended. The scales usually put on sectors are of two kinds—single and double; that is to say, such as are drawn only on one of the limbs, and such as are drawn on both limbs. The first kind, however, (comprising, for example, a line of inches, of chords, sines, logarithms, &c.) are not peculiar to the sector, but are merely placed there for convenience, and may be used whether the instrument is shut or open. Of the lines repeated on both limbs, the principal are the following:—1. A line of equal parts, by which, with a pair of compasses, we are enabled, on the principle that similar triangles have their homologous sides proportional, to find a third proportional to two given lines, a fourth proportional to three given lines, to diminish a line in any given proportion, &c. 2. A scale of chords, which enables us to protract an angle of any given number of degrees, to find the degrees which any given angle contains, to cut off an arc of any given magnitude from the circumference of a given circle, &c. 3. Scales of sines, tangents, and secants, whereby the length of the trigonometrical lines corresponding to a given arc of a circle of any radius are determined. 4. A line of polygons, whereby the proportional length of the side of any regular polygon (of not more than 12 sides) to the radius of the circumscribing circle is found.

The sector may be used in trigonometry for obtaining a rough solution of all the cases of right-angled plane triangles; and it is also conveniently applied to the construction of various geometrical problems.

SEGGAR is the fire-clay cylindrical vessel in which earthenware is baked.

SELENIUM, from Σελήνη, the moon, is a metalloid principle, discovered by Berzelius, in 1817. It occurs sparingly in combination with several metals, as lead, cobalt, copper, and quicksilver, in the Harz, at Tilkerode; with copper and silver (*Eukairite*) in Sweden, with tellurium and bismuth in Norway, with tellurium and gold in Siebenburgen, in several copper and iron pyrites, and with sulphur in the volcanic products of the Lipari Islands. Selenium has been found likewise in a red sediment which forms upon the bottoms of the lead chambers in which oil of vitriol has been made from peculiar pyrites, or pyritous sulphur. The extraction of selenium from that deposit is a very complex process.

Selenium, after being fused and slowly cooled, appears of a bluish-gray color, with a glistening surface; but it is reddish-brown, and of metallic lustre, when quickly cooled. It is brittle, not very hard, and has little tendency to assume the crystalline state. Selenium is dark red in powder, and transparent, with a ruby cast, in thin scales. Its specific gravity is 4·30. It softens at the temperature of 176° F., is of a pasty consistence at 212°, becomes liquid at a somewhat higher heat, forming in close vessels dark yellow vapors, which condense into black drops; but in the air the fumes have a cinnabar red color.

SEMOULE. The name given in France, and used in this country, to denote the large hard grains of wheat flour retained in the bolting machine after the fine flour has been passed through its meshes. The best semoule is obtained from the wheat of the southern parts of Europe. With the semoule, the fine white Parisian bread called *gruau* is baked. Skilful millers contrive to produce a great portion of semoule from the large-grained wheat of Naples and Odessa.

SEPIA. In the fine arts, a species of pigment prepared from a black juice secreted by certain glands of the *sepia* or cuttlefish, which the animal ejects both to darken the water when it is pursued, and as a direct means of annoyance.

All the varieties of the sepia yield this juice; but the *Sepia officinalis*, which is so common in the Mediterranean, is chiefly sought after, from the profusion of color which it affords. It is insoluble in water, but is extremely diffusible through it, and is very slowly deposited. When prepared with caustic lye, it forms a beautiful brown color with a fine grain, and has given name to a species of drawing now extensively cultivated for landscapes and other branches of the fine arts. The honor of the invention of the sepic drawing is due to Professor Seidelmann, of Dresden, who discovered it at Rome in 1777.

SERGE. A cloth of quilted woollen, extensively manufactured in Devonshire and other English counties.

SERPENTINE is a mineral of the magnesian family, of a green color; it is scratched by calcareous spar, it is sectile, tough, and therefore easily cut into ornamental forms.

Its most abundant locality in this country is at Hoboken, N. J., and in Vermont.

SEWER. In architecture, a subterraneous conduit, or channel, to receive and carry off the superfluous water and filth of a city. The sewers of Rome have been the models of those of the modern cities of Europe. They are as old as the elder Tarquin. These *cloacæ* had, between the Quirinal, Capitoline, and Palatine hills, many branches, which joining in the Forum, now the Campo Vaccino, were received for conveyance into the Tiber by a larger one called the *cloaca maxima*. It must be admitted, however, that it is erroneous to designate the Roman cloacæ by the term sewers. They were rather drains, made to carry off the stagnant water of the pestilential marshes which occupied much of the low ground near the Tiber, and the spaces between the Aventine, Palatine, and Capitoline hills. The height and width of the cloaca maxima are equal, each measuring 13½ feet.

Sewers. The whole length of sewers in the City of New York, at the close of the year 1850, was 125 miles, and during the present year there have been added, including what is now under contract, about 11 miles, making 136 miles in all, to be completed within the present year. The number now in progress is 54, at an average length of 800 feet; the average contract price of which is $3 12½ per cubic foot. In addition to this, the contractors are uniformly allowed $2 per cubic yard for excavating rocks. Before this uniform price was established, it frequently happened that bidders at a high *nominal* price obtained a contract in preference to a lower bidder, on account of a different estimate of the cost of blasting, or otherwise excavating the rocks, in which there is a great difference, not always ascertainable before the work is done. On the present plan the contractors, with a knowledge of the rates to be allowed, are supposed capable of judging of the proper rate for building the sewer, and their bids are always made with reference to the fact.

In consequence of sewers not formerly being properly built, many of the old ones have required repairs which, under the present system of management, will rarely be necessary. No person is now appointed to the office of inspector who is not a *practical mason*, and in the absence of personal knowledge a certificate is required that the applicant has served a regular apprenticeship to that business. The care of the department, in the rigid enforcement of its rules, the exaction of sufficient bonds, and evidence of the actual fulfilment of contracts, has produced better work, and is more fully performing its appropriate agency for the city than at any time heretofore.

Among other improvements, the form of the sewer has been changed from a round to an oblong, or rather an egg form, having the smallest diameter at the bottom. This does not alter the capacity of the sewer, but causes greater velocity of current, and helps the sewer to cleanse itself. This it would effectually do if the department should carry out the plan to which they have given some consideration, of *flushing* the sewers by means of the waste pipes of the Croton, in which case they would accumulate but little filth. The sluices are now so constructed that while they readily receive the water as well as the mud from the surfaces and gutters at every rain, the contaminated air is effectually prevented from rising. The accumulation of dirt in these sluices is, in some localities, very great, two hundred loads having been, in one instance, taken from a single block in Canal-street.

The depth of the sewers is various, according to the grade of the street or district requiring to be drained. At their termination in the rivers, they are, as a general rule, between two and three feet below high water mark. From this point they rise with the average grade they are intended to drain, till they reach a nearly uniform rate of 13¼ feet below the curb stones. In some instances, however, the depth is 17 feet or more, where the grade of the street is more than of ordinary height—the object being to obtain in each instance the requisite *average* of elevation. For the necessary fall of water three inches in 10 feet is regarded sufficient—but a greater rate is usually allowed.

In connection with the use of Croton water, the sewers are invaluable, and the *full* benefit of the Croton could not be obtained without them. To perceive this, it is scarcely necessary to refer to the facilities afforded in bathing-houses, water-closets, manufactories, hotels, and other places, where large quantities of water, more or less impure, must flow off through the sewers, or render the atmosphere unwholesome by being discharged upon the surface of the ground.

So important a matter is it now regarded by builders and owners of lots, that scarce a building is now commenced without an inquiry first at the Croton Water Department whether the street has a sewer, and at what depth a cellar may be expected to be drained. This is the more important, since by the disuse of wells, the level of water in the city has generally risen to a higher line than formerly.

The cost of the 54 sewers now under contract, to be completed within the present year, is about 135,000 dollars.

SEWING-MACHINES. Machines of this kind, until within a few years, have attracted but little attention; but as they are coming into use, and are found to answer an excellent purpose, the inventor is ingeniously exercising his skill to improve them. No less than five patents have been granted this year for sewing-machines. One of these is a re-issue of a patent granted some years ago, and need not be noticed. Two of the others are much alike, differing only in minor particulars. The cloth in each, with its edge properly presented to the needle, is secured to a proper feeding apparatus. The needle is placed perpendicular to the cloth, in a frame sliding back and forth for inserting and withdrawing it; the eye is near the point. On the opposite side of the cloth is a twisted hook, which slides endwise in a direction nearly perpendicular to the needle; as the needle passes through, the thread is caught by the hook and drawn sidewise, forming a loop. When the needle again passes through the cloth, it passes through this loop also, and the hook moves forward, releasing the old loop and seizing the new thread, forms a new loop passing through the old one. This operation combined produces what is well-known as the tambour stitch. In another of these machines the thread is carried through the cloth by a bent needle, with the eye near the point. The shape of the needle leaves a space between it and the thread. A shuttle upon a circular way on the side of the cloth opposite the needle, has in it a bobbin of thread. This shuttle is sharp pointed and curved to adapt it to the way, and as it moves around it passes through the opening beween the needle and the thread, and the needle is then withdrawn, leaving a loop of its own thread around the thread of the bobbin. This, if continued, will produce a seam. The shuttle is driven by two arms from the centre shaft with pins in their ends taking into perforations one in each end of the shuttle, and whenever one of these pins approaches the thread of the needle, it is raised out of the way and the shuttle is driven by the other.

Various forms of these machines have been patented, such as Watson's, Wilson's, Lerow and Blodgett's, &c.

SHAFT. In mines. A shaft or pit is a prismatic or cylindrical hollow space, the axis of which is either vertical or much inclined to the horizon. The dimensions of the pit, which is never less than 32 inches in its narrowest diameter, amounts sometimes to several yards. Its depth may extend to 1000 feet, and more. Whenever a shaft is opened, means must be provided to extract the rubbish which continually tends to accumulate at its bottom, as well as the waters which may percolate down into it; as also to facilitate the descent and ascent of the workmen. For some time a wheel and axle erected over the mouth of the opening, which serve to elevate one or two buckets of proper dimensions, may be sufficient for most of these purposes; but such a machine becomes ere long inadequate. Horse-whims, or powerful steam-engines must then be had recourse to; and effectual methods of support must be employed to prevent the sides of the shaft from crumbling and falling down.

SHAGREEN. A species of leather, supposed formerly to have been prepared from the skin of the *shagree*, a species of whale. It is prepared from horse or ass skin, its granular appearance being given by imbedding in it, while soft, the seeds of a species of chenopodium, and afterwards shaving down the surface: it is dyed with the green produced by the action of sal-ammoniac on copper filings. It was formerly much used for watch, spectacle, and instrument cases, and was made chiefly in Astracan.

SHAMMY, or SHAMOY. The tanned or tawed skin of the Chamois goat. Any soft pliable leather now passes under the name. *See* LEATHER.

SHAWLS, CASHMERE. The secret of the quality of these shawls is not in the working; it is in the beautiful wool from the goats of the Upper Thibet, the equal of which in softness has never yet been found. The goats live in high table-lands of Tartary, where the cold is intense, and to protect them from the piercing blast of winter they have the under-hair or "Poshai," of this deliciously soft and warm material. This wool is brought down to Cashmere once every year by merchants, and sold to the shawl-makers. After thorough cleaning, it is dyed of various colors; the dyers possess the vegetable or mineral ingredients for all the colors except green, and this they procure from English green baize by boiling. The color thus obtained is a most beautiful and enduring one, and is very much prized by Mohammedans, being their holy color, to be worn only by descendants of the Prophet, or those who have made the pilgrimage to Mecca. The shawl patterns are drawn upon paper, very minute, and with the greatest possible accuracy; fifty rupees are sometimes paid for the mere drawing of a very elaborate pattern. The dealers in shawls are the agents of merchants residing in Bombay, Delhi, Lahore, and having branch establishments throughout Asia. These dealers give the order and advance the money to the shawl manufacturer; he makes only to order from the dealer or middleman, and is entirely dependent upon him. The loom is that of the commonest kind, the buildings in which the men work low, confined, and ill-ventilated. Each man (for no women work at the loom) sits with his little bundle of colored wools wound upon small spindles, and a written paper before him, by which he is entirely guided as to the number of threads, &c., to take up. He works distinct from his neighbor, on his own loom; and as all shawls are made up of small pieces, each piece being about eight inches long, by four wide, the qualities of every workman can easily be detected. The most skilful earn about eight anas (equal to 25 cents) per day; this sum is, however, equivalent to a much larger amount, if reckoned at what it will procure. These small pieces, when finished, are made over to the agent or dealer, who has them sewn together in a coarse manner, to judge of the general effect—they are afterwards washed in particular places in a stream branching from the river, and the water is said to possess peculiar properties in softening the wool, and bringing out the brilliancy of the colors not found in any other spot. But few people visit Cashmere for the purpose of purchasing shawls; the agents despatch the shawls, after they have been washed, to the larger marts in Asia, and from their correspondents the local merchants purchase them. Besides the shawl, there are several varieties of dress made from the wool—one the Ahlwan, perfectly plain, of a dirty-white drab, and lilac colors; the texture seems delightfully soft, but the large price asked for a piece five or six yards in length, seemed far above the value. The shawl manufacture above described is that of the genuine and much prized kind; an inferior sort called the "zozuni," or sewn, is that in which there is a plain groundwork of wool, the Ahlwan dyed of any color, upon which the shawl pattern is worked with the needle. Many of these are very beautiful in appearance, and of most elegant patterns, but to the eye of the connoisseur they are almost destitute of value. The "fumawali" is a striped shawl material, wove in the piece, and used for dressing-gowns, ladies' dresses, or for the alkaluk worn by the nobles of Lucknow in the cold weather.

SHEATHING. The covering laid on the ship's bottom to defend it from the worms. Sheets of thin copper nailed on with copper nails constitutes, at present, the sheathing of all the better kinds of vessels. Lead has been used; and large-headed iron nails, called scupper nails, are used still for the same purpose on the bottom of old hulks, piles, &c. Zinc and different compositions have been proposed as substitutes for copper; and Sir H. Davy ingeniously suggested the application of pieces of zinc or iron upon different parts of the copper surface, which by the action of the sea water render the latter metal electro-negative, and capable, therefore, of resisting the oxidizing and corrosive agencies of the substances held in solution. The pieces of iron or of zinc so applied have been properly called *protectors;* but by occasioning the precipitation of earthy matters upon the copper, while they effectually *protect it,* they render its surface favorable to the adhesion of weeds, barnacles, &c., and sometimes to such an extent as to interfere with the passage of the ship through the water: upon such grounds, Sir Humphrey's valuable suggestion has been neglected. When vessels are laid up in dock the protectors are in successful use. Sheathing formerly was composed of thin fir boards.

SHELL-LAC. *See* LAC.

SHINGLES. In architecture, small slabs of wood, or quartered oaken boards, used instead of slates or tiles for covering churches or houses. They are sawn to a certain scantling, or rather cleft to about an inch thick at one end, and shaped like wedges, four or five inches broad, and eight or nine inches long.

SHIP-BUILDING. In merchantmen, the primary consideration is, to attain the greatest capacity to carry cargo, combined, as far as possible, with safe and easy movements, and rapid sailing. In this way American builders have succeeded in uniting conflicting *desiderata* in a degree heretofore deemed impossible. Our packet ships carry enormously, while their extreme speed has reduced, by half, the passage to Europe.

The greatest breadth must always be before the centre, and consequently, the bow be more blunt than the stern. The best builders place this point only one third of the length from the stem. Experience proves that it is essential to facilitate the escape of the displaced water along the side of the vessel; for, when once a passage is opened for the ship, the fluid tends to re-unite abaft the point of greatest breadth, where, instead of offering resistance, it presses the ship forward in its endeavor to recover its level and fill the vacuum constantly opening behind her. A log tows infinitely easier by its bigger end; and we find a concurrent testimony in the forms of the finny tribes which divide the element they move in, by a shape gradually diminishing from head to tail. There is a further advantage in having the bow full towards the edge, that it may check descending into the waves, not abruptly, but gently; pitching being the most dangerous to hull and spars of all movements. Sharpness towards the sternpost is vitally essential to fast sailing. Stability increases as the cubes of the breadth; hence, by adding one quarter to the breadth, you gain a double stability, and, by consequence, a capacity to bear twice as much sail, with but one fourth of increase in the resistance. The pressure of the water increases in descending from the surface, and, from this cause and the augmented difficulty of displacing it, the resistance offered to a ship, in advancing, is three times as great at the lower as at the upper half of the immersed section. An extreme in breadth, as in length or depth, is also dangerous, and both extremes are to be equally avoided.

The builder forms a half model of his proposed ship, making it a quarter of an inch to the foot. Moulds are then formed of all the different parts. In these United States, where there are abundant supplies, builders confine themselves to live oak, pine, chestnut, locust, and cedar. The tree should be taken in the second era of its growth, when it has attained maturity, without approaching the period of decay. It should be killed, by removing a ring of bark, at the beginning of winter, when the sap is down, and left to dry and harden before it be cut down.

In laying down the keel, great care must be taken to preserve its perpendicularity, for which purpose it is pinned with treenails on either side of the blocks: also in raising and propping the stem and stern, and every piece of the frame. As the floor timbers are the great connecting principles of the ship, to which they bear the same relation as the ribs to the body, too much care cannot be taken in selecting and securing them. Sometimes the frame is made completely solid and calked; and, in this case, the interior covering of plank is dispensed with, excepting a few strengthening streaks.

The planking does not merely serve to exclude the water, but to protect, connect, and bind harmoniously together, and is quite as essential as the skin to the body. It is one of the nicest arts of the builder so to carry up his planking, as with little waste, to keep his seams always fair with the water-lines. When it is necessary to bend a plank at the bow or stern, it is heated by steam, and then forced into place with screws and levers. All being complete, the carpenter makes room for the calker, who carefully stops all the seams with oakum, and smears them with pitch. The scraper follows the calker. Sheathing with wood is practised with iron-fastened ships, because copper causes the bolt-heads to corrode, if placed against them. It consists in covering the bottom with pine boards, sheets of paper soaked in hot pitch being placed between.

Two varieties of sails are principally in use—the square rig, and the fore-and-aft sail. In the *square rig*, square sails are attached to yards, whose primitive position is at right angles to the masts and to the plane of the keel; but which are free to move round the mast. In the *fore-and-aft rig*, the primitive position of the sail is in the plane of the keel; and the sail is extended at the top and bottom, by spars, known respectively as the gaft and boom: these are attached by crotches to the mast and are free to slide up and down it. Common to both of these rigs are the head sails or jibs—which are triangular in shape and extended from the bowsprit to the foremast head.

In the naval service, the *first rate* is a ship of the line of one hundred guns or upwards, having three decks or tiers of guns; and the seventy-four is of the line but *third rate*, with two decks or tiers of guns. The titles of *sloops*, *brigs*, *corvettes*, and *cutters*, are applied to the smaller sizes of vessels. In the merchant service, a *ship* has three masts, all square rigged; a *bark* has also three masts, but carries square sails on the fore and main-masts, and a fore-and-aft sail on the mizen-mast. A *brig* has two masts, and is square rigged. A *brigantine* or *hermaphrorite brig* has two masts, and is square rigged on the fore, and fore-and-aft rigged on the main-mast. A *schooner* has two masts, both rigged with fore and-aft sails; sometimes a topsail is added, and the title is changed accordingly to *topsail schooner*. A *sloop* has only one mast, and is fore-and-aft rigged.

If we compare the carcase of a ship to the skeleton of the human body, the keel may be considered as the back-bone, and the timbers as the ribs. It, therefore, supports and unites the whole fabric, since the stem and stern-post, which are elevated on its ends, are, in some measure, a continuation of the keel, and serve to connect and inclose the extremities of the sides by transoms; as the keel forms and unites the bottom by timbers. The keel is generally composed of several thick pieces, placed lengthways, which, after being scarfed together, are bolted and clinched upon the upper side. When these pieces cannot be procured long enough to afford a sufficient depth to the keel, there is a strong thick piece of timber bolted to the bottom, called the false keel.

A new era has taken place in the art of ship-building; and we are indebted to Sir Robert Seppings for some of the most important improvements in marine architecture which have characterized the present century. Several large ships have already been rebuilt at Chatham on his principle, and orders have been given for building several new ships.

1st. The frame of a 74 gun ship, used to be formed of more than 800 different timbers, placed at right angles to the keel, which may be considered as the back-bone of an animal, and the frame-timbers its ribs. Each rib is composed of separate pieces, of the thickness of 14 inches, or thereabouts. Between the several divisions of the frame or ribs, is a space from 1 to 5 inches wide.

2dly. The whole exterior frame was covered with planks of different thicknesses, or, to carry on the figure, the ribs are covered by a skin of greater or less substance, from the extreme ends of them to the keel or back-bone. The inside of the frame was also almost entirely lined with planks; within which is another partial range, as it were, of interior ribs, at a considerable distance from each other, termed riders.

3dly. Across this frame were pieces of timber called beams, united together so as to be of sufficient length to reach from one side of the ship to the other.

From this account, it will be perceived that all the materials composing the fabric of a ship, are disposed nearly at right angles to each other. And this disposition, which is well known to be the weakest, is particularly so in a ship, the immense body of which, subject to violent action from impulses in every direction, is sustained by a greater pressure on the centre than the extremities, arising chiefly from the difference in the fore and after parts of the body, to that of the midship or middle part.

The length of a 74 gun ship being 170 feet or more, it requires but little knowledge of the strength of timber to perceive that planking of that length, however thick, or in whatever way joined or put together, must, under the present system, bend with its own weight. The fastenings, and, consequently, the connection of the several parts of the fabric, must therefore suffer from the want of *stiffness*, and a change of form is the consequence.

This may be shown by putting together four pieces of wood, and then securing them with iron pins in the form of a square; which, on the least pressure, may be made to change its form to the rhombus; but let another piece be fixed to it *diagonally*, and the figure of the frame will be found *immovable*. Place a bar in the middle, parallel to two of the sides, and secure it firmly by iron pins; still the figure will easily be moved by the hand, *like a parallel ruler*, and assume the rhomboidal shape; but apply to the frame what the carpenters term *the brace*, as in a common field-gate, and the figure will remain immovable. And if this brace or diagonal piece is not fixed to it, the outer part of the gate (or that part most distant from the hinges) will have a constant tendency downwards, until at length it will reach the ground.

The substitution of *the triangle*, or brace, for the rectangle, comprehends *the principle of the new system.*

The arrangement of the materials in the triangular mode is such, that the pieces disposed horizontally are acted upon as ropes by a strain of the fibre, whilst the other parts, composing a series of triangles, are pressed upon as pillars; in other words, the pressure acts in the direction of the fibres of the wood; whereas, upon the rectangular or old plan, the fibres are acted upon transversely, or across the grain, in the same manner as a stick is when placed across the knee, and pressed by the hands at each end, which first bends, and then breaks.

To prevent any transverse action upon the fibre of the timber is one of the benefits arising from the new system, and to impede a longitudinal extension of the structure, is another. In a word, *the system of triangles* is so constructed, in conjunction with the planking of the ship, as conjointly to possess that property of a triangle already explained, viz., *that its figure is as unalterable as the compression or extension of the fibre of timber will admit it to be.*

There is considerable difference in the details of ship-building as carried out in the United States compared with that of England. Even the technical terms of the art differ in the two countries. Few vessels here are built from the draught. In Europe, the line of flotation, or the inscribed line at the surface of the water, is called the first water line, or load line, and as they descend the figures increase. In this country, the lowest water line is denominated the first, and the numbers increase as we ascend.

Mr. Pook, naval constructor at Charlestown, Mass., has discovered an ingenious mode of determining the capacity of vessels, which is of ready application, and is adapted to all descriptions of freighting vessels; sharp vessels, and our ocean steamers are exceptions, however, to its application. The rule is; from 90° deduct the angle of the floor, or the degrees of dead rise; multiply by ·0075, the quotient is the decimal for capacity. Multiply the length by the breadth, and that product by the depth, from the bottom of the garboard to the load line, and the last product by the decimal of capacity, and divide by 35, the quotient is the capacity in tons.

The navigation laws of this country have a very injurious effect upon ship-building, by building for tonnage rather than for quick sailing. A short time since it was thought necessary for a ship to draw more water aft than forward, in order to obey the helm readily, and this was made to appear on the water lines by the latter dipping considerably lower than the former. This practice has grown obselete, and parallel water lines are used. Mr. Griffiths, in his work on *Marine and Naval Architecture*, remarks, that the idea would have been regarded as preposterous of building a ship deeper forward than aft, but such is the present practice of New York, where it was first introduced, and the results have proved most satifactory, ships having been built in this city having from 3 to 5 feet of difference in depth at their ends, which adds greatly to their appearance as well as their performance. Stability of vessels in water is desirable, but to what this property is due is not yet decided. It is in part due to the breadth of the vessel compared with her general dimensions. Thus, increasing the beam, or a less proportion of depth, increases the stability. The steamer Georgia is the widest vessel of her class, except the Great Britain, but yet is one of the easiest vessels in her motions that floats. She is 3 feet wider than the Ohio, and wider than any of the Collins line, which are much larger than the Georgia. The Cunard steamers are narrower, though longer and deeper. The America and Europa have but 38 feet of moulded beam, and the Canada but 39¼ feet, while the Georgia, with ten more feet of beam, has more practical stability than any European steamer. What is true of steamers is true of ships. They may be built so long and so wide that the motion of the sea will not be felt, that is, they will neither roll nor pitch.

An easy or light draught of water is essential to speed, and therefore to river navigation; it is generally looked for in shape, whereas it probably should be sought in the nature of the material and in the density; very light draught iron boats are superior to wood. Other circumstances concur to favor the use of iron, such as the rapid rotting of the timber of the West Indies, South America, and even of that of our Southern States; hence, for low latitudes, where ventilation is not perfectly effected, iron ships are more durable. The cost of iron is, however, 25 per cent. more than that of wood. But the saving afterwards effected is an ample compensation. The water tight bulk-heads would be a valuable adjunct in Mississippi vessels. These prevent the boat from sinking, even though a part be snagged and full of water. The "Reindeer," on the Hudson River, is a model of speed even among the fast sailing vessels of that river. (*See* STEAM NAVIGATION.) She was built by Mr. T. Collyer, in 1850. She is not the largest, but is the fastest wooden steamer in the Northern States. Her dimensions are, length, 260 feet; breadth, 34·08 feet; depth amidships from bare line to deck line, round of beam deducted, 9·75 feet; area of her immersed midship section, 119 square feet. Diameter of the cylinder, 56 inches; stroke of piston, 12 feet; diameter of the water wheel, 34 feet; face of wheel, 9 feet 6 inches; width of the bucket, 24 inches; calculated dip, 9 inches. Vertical beam engine. Balance valves with Stevens' cut off. The weight of the boiler is 87,487 lbs. Weight of the boat at 4 feet draft of water, 147 tons 417 lbs.

In river steamers there should be a due relation between the proportion of the boiler and the wheels. When the latter turns fast enough to reduce the pressure in the boiler, there is either more wheel or more boiler required. Mr. Stevens proposes to increase the speed of steamboats, by interposing a stratum of air between the flat surface of the bottom and the water. Mr. S. has effected little with this himself, although he has built a vessel little inferior in speed to any wooden boat of equal length on the Hudson, viz., an iron boat of 280 feet long, and unusual shape.

Ocean steam-ships for speed require to have their bows made very sharp, so that even at the highest speed even the smallest resistance be not generated. A full bow generates resistance, and to drive that form of bow on with increased force, is only increasing the resistance and the difficulty. When it is very sharp, however, she has no buoyancy, and becomes very wet, or liable to ship seas. If speed be required in ocean steam-ships, they must have length. The steam-ship Georgia, already alluded to, is the quickest sailing steamer in the United States. She has the small end ahead, and has run 1000 miles within 60 consecutive hours, or equal to 400 miles per day. Her mean load line of draught is 16 feet, beimg all that is available in running to New Orleans.

The coasting vessels of the United States combine great variety of shape and dimensions. There are vessels built of considerable size which run on a draught of 3 feet, and from that up to 10 feet, and are on account of their breadth the most stable vessels in the world. Some have a centre-board or movable keel; some have a deep keel; some have no centre-board, and a small keel. There are a large class of vessels built in New England principally for, and engaged in, the lumber trade, which not unfrequently carry from one-half to five-eighths of their cargo on deck. Almost all the yellow pine timber brought from the south comes in these vessels. The timber which is in the log, and very long (55 to 75 feet), is carried on deck, while the shorter lengths are taken in the hold, through a lumber port cut in the bow immediately below the deck. Their great fault is lowness of the bow, rendering them so liable to ship seas and get wrecked.

The famous Baltimore clippers are now being superseded, as being too small—the increased speed not making up the difference in dimensions. They are also too deep for the coasting trade of this country. Clipper ships of large size, with comparatively less draft of water, are now being built to a great extent along the eastern coasts, especially in this city (N. Y.) and in Maine. The pilot boats are not only the best, but the fastest vessels on our coast. These are vertically sharp in their bows, and thus part the water while vessels with round bows ride over it. One of these, the *Mary Taylor*, built by Mr. S. Steers, of New York, is looked upon as the model craft of this kind of vessel, and has far surpassed the expectation of her owners.

The river sloops, rigged like English cutters, are also very fast sailing vessels, and carry on much of the inland commerce of this country. They are chiefly employed on the Hudson and East Rivers, (N. Y.) in carrying freight. Their great breadth enables them to carry enormous deck loads. The round of the deck transversely exceeds that of any other kind of vessel, being often more than 12 inches in 26 feet.

During the present year (1851) a triumph of American over English ship-building has been achieved, in the case of the yacht, the schooner *America*, built and owned by Mr. Stevens, of New-York, which sailed for and obtained the prize (value £100) of the Royal Yacht Club of England at the regatta which came off at Cowes on 22d August, 1851. The yacht came in 52 minutes ahead of the foremost English vessel. She has since been sold for $25,000, being about $5,000 more than it cost in New-York. She has a clipper build, with a low, black hull, and two masts of extreme rake without extra rope. Her bow is very sharp, and scooped away outward, swelling toward the stern. The sides gradually spring outward till a little forward of the mainmast, where she has her greatest beam, being 22 feet 8 inches there. The stern is broad, wide, and full, affording great accommodation above deck and below. The bulwarks are not higher than 10 inches. Standing at the stern and looking forward, the deck is nearly of a wedge shape, or like the section of a carrot, the bow being as sharp as the apex of a triangle, and the stern being little less than the extreme breadth of the beam. She is of 171 tons burthen.

In the year ending June, 1850, the merchant ships which left port in the United States amounted to 18,195, of which 8,379 were American, and 9,816 foreign. The tonnage of these vessels was 4,361,202 tons. From New-York alone the number of ships cleared was not less than 2,818 of 1,106,070 tons. In 1850 there were built and launched from New-York 28 steamships and 30 sailing vessels.

The following statement shows the number and tonnage of the vessels built in each state and territory of the United States, for the year ending on the 30th of June, 1850. It is taken from the Report of the Secretary of the Treasury, transmitting the annual report of the Register of the Treasury of the commerce and navigation of the United States for the fiscal year.

Of the vessels comprised in the table, there were two hundred and forty-seven ships, one hundred and seventeen brigs, five hundred and forty-seven schooners, two hundred and ninety sloops and canal boats, and one hundred and fifty-nine steamers. The largest number of ships built in any state was one hundred and twenty-seven, in Maine; and the largest number of steamers, thirty-four, in Kentucky. The largest tonnage set afloat during the year is that of Maine, and the next largest of New-York. Of the one hundred and fifty vessels built in Maryland, one hundred and twenty-five were schooners.

States.	Vessels Built.	Total Tonnage.
Maine	326	91,211 73
New Hampshire	10	6,914 32
Vermont	1	77 41
Massachusetts	121	35,836 14
Rhode Island	14	3,587 16
Connecticut	47	4,819 79
New-York	224	58,342 73
New-Jersey	67	6,201 68
Pennsylvania	185	21,409 93
Delaware	16	1,848 92
Maryland	150	15,064 80
District of Columbia	8	288 17
Virginia	34	3,584 04
North Carolina	33	2,651 59
Georgia	5	683 82
Florida	2	79 75
Alabama	3	113 66
Louisiana	24	1,592 38
Kentucky	34	6,460 69
Missouri	6	1,353 82
Illinois	13	1,691 21
Ohio	31	5,214 62
Michigan	14	2,061 63
Texas	1	106 54
Oregon	2	122 42
Total	1,360	272,218 54

SHOT. Under the article Lead-Shot has been given the usual process for manufacturing this substance.

It is well known that for a number of years past, all our shot for fowling-pieces has been manufactured by dropping the molten lead a great distance. For this purpose tall towers were erected. An invention has been patented both at home and abroad, by Mr. David Smith, of this city, designed to make the shot in any building, to obviate the necessity of using tall towers; the principle of the invention is highly ingenious, and consists in driving a current of air in a contrary direction to the falling lead, which combined with the velocity of the falling lead from a low height (about 50 feet) will cool the metal as well as if it fell from a great height; the velocity, according to the size of shot desired, being the cause of this.

SHUTTLE. An instrument used by weavers, which guides the thread it contains, so as to make it form the woofs of stuffs, cloths, linen, and other fabrics, by throwing the shuttle alternately from left to right and from right to left across between the threads of the warp, which are stretched out lengthwise on the loom. In the middle of the shuttle is a kind of cavity, called its eye or chamber, in which is enclosed the *spool*, which is part of the thread destined for the woof.

SIENITE is a granular aggregated compound rock, consisting of feldspar and hornblende, sometimes mixed with a little quartz and mica. The hornblende is the characteristic ingredient, and serves to distinguish sienite from granite, with which it has been sometimes confounded; though the feldspar, which is generally red, is the more abundant constituent. The Egyptian sienite, containing but little hornblende, with a good deal of quartz and mica, approaches most nearly to granite. It is equally metalliferous with porphyry; in the island of Cyprus, it is rich in copper; and in Hungary, it contains many valuable gold and silver mines.

Sienite forms a considerable part of the centre of Staten Island. It takes its name from the city of Syene, in the Thebaid, near the cataracts of the Nile, where this rock abounds. It is an excellent building-stone, and was imported in large quantities from Egypt by the Romans, for the architectural and statuary decorations of their capital.

SILICA and SILICON. Silica was till lately ranked among the earths proper; but since the researches of Davy and Berzelius, it has been transferred to the chemical class of acids. It constitutes the principal portion of most of the hard stones and minerals which compose the crust of the globe; occurring nearly pure in rock crystal, quartz, agate, chalcedony, flint, &c. Silica or silicic acid may be obtained perfectly pure, and also in the finest state of comminution, by taking the precipitate formed by passing silicated fluoric gas through water, filtering, washing, and igniting it, to expel the last traces of the fluoride of silicon. The powder thus obtained is so light as to be blown away with the least breath of air. Silica may be more conveniently procured, however, by fusing ground flint with four times its weight of a mixture, in equal parts, of dry carbonate of potassa and carbonate of soda, in a platinum or silver crucible. The alkaline carbonates should be first fused, and the flint powder sprinkled into the liquid, as long as it dissolves with effervescence. The mass is to be then allowed to cool, dissolved in dilute muriatic acid; the solution is to be filtered, and evaporated to dryness; the dry crust is to be pulverized, digested for two hours with a little muriatic acid, to remove any iron and alumina that may be present, next washed with hot water, drained, dried, and ignited.

The above silicate of potassa and soda is the compound called soluble glass, which applied in solution to the surface of wood, calico, paper, &c., renders them unsusceptible of taking fire on the contact of an ignited body.

Silica, as thus prepared, is a white powder, rough to the touch, gritty between the teeth, absolutely insoluble in water, acids, and most liquids. Its specific gravity is 2·66. It cannot be fused by the most intense heat of our furnaces, but at the flame of the oxy-hydrogen blowpipe it melts into a limpid colorless glass. By peculiar chemical methods, an aqueous solution of it may be made artificially, similar to what nature presents us with in many thermal springs, as in those of Reikum and of Geyser in Iceland, and of most mineral waters, in minute quantity. There is no acid except the fluoric which can directly dissolve dry or calcined silica. Silica is composed of 48·04 silicon, and 51·96 oxygen.

SILICATES are compounds of silicic acid (silica), with the bases alumina, lime, magnesia, potassa, soda, &c. They constitute the greater number by far of the hard minerals which incrust the terrestrial globe. Thus cyanite is a subsilicate of alumina; feldspar and leucite, are silicates of alumina and potassa; albite and analcime, are silicates of alumina and soda; stilbite, prehnite, mesolite, labradorite, tourmaline, mica, &c., are silicates of alumina and lime; chrysolite, steatite, serpentine, and meerschaum, are silicates of magnesia; augite and hornblende, are silicates of lime and magnesia, &c.

SILK. A fine glossy thread or filament spun by various species of caterpillars or larvæ of the *Phalæna* genus. Of these, the *Phalæna atlas* produces the greatest quantity; but the *Phalæna bombyx* is that commonly employed for this purpose in Europe. The silkworm, in its caterpillar state, which may be considered as the first stage of its existence, after acquiring its full growth (about three inches in length), proceeds to enclose itself in an oval-shaped ball, or cocoon, which is formed by an exceedingly slender and long filament of fine yellow silk, emitted from the stomach of the insect preparatory to its assuming the shapes of the chrysalis and moth. In this latter stage, after emancipating itself from its silken prison, it seeks its mate, which has undergone a similar transformation; and in two or three days afterwards, the female having deposited her eggs (from 300 to 500 in number), both insects terminate their existence. According to Reaumur, the *phalæna* is not the only insect that affords this material—several species of the *aranea*, or spider, enclose their eggs in very fine silk.

Raw silk is produced by the operation of winding off, at the same time, several of the balls or cocoons (which are immersed in warm water, to soften the natural gum on the filament) on a common reel, thereby forming one smooth even thread. When the skein is dry, it is taken from the reel and made up into hanks; but before it is fit for weaving, and in order to enable it to undergo the process of dyeing, without furring up or separating the fibres, it is converted into one of three forms—viz. *singles*, *tram*, or *organzine*.

Singles (a collective noun) is formed of *one* of the reeled threads, being twisted, in order to give it strength and firmness.

Tram is formed of two or more threads twisted together. In this state it is commonly used in weaving, as the *shoot* or *weft*.

Thrown silk is formed of two, three, or more singles, according to the substance required, being twisted together in a contrary direction to that in which the singles of which it is composed are twisted. This is termed *organzining*; and the silk so twisted, *organzine*. The art of throwing was originally confined to Italy, where it was kept a secret for a long period.

Silk is commencing to be cultivated very extensively in this country. One of the most successful growers is Mr. Byram, Brandenburg, Meade co., Kentucky.

Experience has fully proved that the climate of the United States is as well adapted to the nature and habits of the silk-worm and the production of silk, as that of any other country. Several varieties of the mulberry being indigenous in our soil, and those generally used in the native country of the silk-worm succeed equally well in our own soil and climate. Hence, from the nature and habits of the American people, we must soon become the greatest silk-growing nation on the earth.

The first step towards the production of silk, is to secure a supply of suitable food for the silk-worm.

Having tried all the varieties introduced into our country, Mr. Byram finds the morus multicaulis and the Canton varieties, all things considered, most suitable for that purpose.

At Economy, Pennsylvania, the rearing of the silk-worm is now carried on to a great extent and more successfully than in any other part of the United States, or perhaps in the world. Their houses are two stories high. The worms are fed on small trays about eighteen or twenty inches wide, and about three feet long. They are supported on frames or hurdles one above the other, and are about six inches apart. When the worms are about ready to wind, they are transferred to the upper story, to permanent shelves, about 16 inches apart, where they form their cocoons in bunches of straw placed upright between the shelves. The worms are cleaned at least once after every moulting, and after the last, every day. For this purpose they have nets wove or knit, of cotton twine, something larger than the size of the trays, with meshes of various sizes suited to the age of the worms. For the last age they are about three-quarters of an inch square. These are used without frames. When it is required to remove the worms from their litter, the nets are laid lightly over them, and then plentifully fed. When the worms have arisen upon the fresh leaves, they are removed by two persons taking hold of the four corners of the net and transferring them to clean trays, held and carried off by a third person. One hundred thousand are changed in this manner in two hours.

The silk-worm is a species of caterpillar, whose life is one continual succession of changes, which, in due time, becomes a moth or winged insect, like others of the genus.

The time occupied in going through its different forms of existence varies in different countries—governed by climate, temperature, and the quality and quantity of the food upon which it is fed, and the nature of the particular variety of the insect.

The worm changes or casts its skin (of the common varieties) four times before it attains its full growth. These changes are called moultings, and the periods intervening between the several moultings are termed ages. When it is first hatched it is of a blackish color, which afterwards becomes lighter, varying almost daily to different shades, and in different varieties through every age, to the close of the last, or near the time of spinning, when it assumes a grayish yellow semi-transparent appearance.

The following directions given by Mr. J. McHannon, Hamilton co., Ohio, for the raising of worms, has been tried in this country, and is recommended. First, have good eggs, well kept, and do not let them hatch till warm weather or in the middle of May. When hatched, lay on leaves, and move them on to clean paper by lifting the leaves. Do not let them get too thick or they cannot be fed enough without covering them too deeply with leaves. Move and spread them every day, except when they are moulting. Feed often with fresh leaves, give them all the air you can, so that they do not blow away. After the first moulting, feed with short, tender twigs. They are easily moved and spread with the twigs in the morning when they are hungry. If they are neglected while young it is useless to feed them while they are old. All the diseases among my worms are caused by neglect, or by keeping them in a close building where there was not enough pure air. After they pass the second moulting, if they are fed with care, they will eat the leaves so clean that they will need to be moved but once between each moulting, and that should be done just before they moult; but should their beds become foul, move them by all means.

Keep each day's hatching separate. The first day but few worms will hatch, and they serve as a guide for all the rest. When they commence moulting, you can move the others on clean papers before they commence moulting.

If the worms are well fed and not too thick on the papers, and the weather warm, they will moult nearly at the same time; that is, each day's hatching, and when they are kept separate and the papers marked 1st, 2d, and 3d day, &c., you can feed them as they ought to be fed, and when they commence winding you can put up the bushes for them to wind in, as each lot commences. They will not all need them at once as they would if all ages were mixed. When all the frames commence winding at once they cannot be attended to in time, and many worms will be lost if there is no place provided for them. They will crawl over the frames and waste their silk; even if they make a cocoon it will be of but little value.

After the third moulting, feed with branches as long as they will lay on the frames. Keep the bed as even as possible. Let no leaves hang over the frame, lest some of the worms crawl out on them, others will cut them off, and leaves and worms will fall together to the ground.

When the worms get too large to lift with the branches, and they want moving, place five strips, three-eighths or one-half inch square, across the frames (the frames are three by four feet, the strips are three feet four inches long), so as to extend two inches over the frame on each side. Sift lime over the whole bed till it is all white, worms and all; then lay branches lengthwise of the frame across the five strips. After feeding a few times the worms will all be on a new bed; they will not stay among the lime in the old bed. They are then ready to move.

Have a few duplicate frames ready; lay two sheets of heavy brown paper that will cover the frame: if you could get one large enough to cover the frame it would be better. Give the worms a good feed, and as they come upon the upper bed, place two strips, four feet long, under the ends of the five cross strips. Two persons can then raise the worms up, while the third person slips the frame and old bed out and places one of the duplicates in its place. The worms can then be let down, and they will keep eating as if nothing had happened.

Cane brush is the best bed for them to wind in. When that cannot be had, cut oak limbs; lay them in the sun to wilt: if they are put up green and the worm commences winding in them the leaves curl and the worm has to leave its place to find a better, and will seldom begin again. Cut the brush of the right length to spring in between the frames. The frames should be eighteen inches apart, three tier, one above the other, the lower one two feet from the ground. When feeding, after the brush are put up, lay the butt-end of the multicaulis branches (nothing else is worth feeding with) snug to the oak bushes, that the worms can get to them when they want to wind. After most of the worms on a frame are gone up, pick off the rest and mark the frame: in four days gather the cocoons, if the weather is warm; if not, in six days. Having the oldest worms in the upper tier, you can take them down without disturbing the rest.

After the cocoons are gathered, select the best for seed. When the millers come out, throw all the poor ones out, if there are any. The papers intended for the eggs, are hung up to keep them clean, as there will be nothing on them but the eggs. To keep eggs from hatching in summer, roll the papers in cotton batting, put it in a wooden box and place them in an ice house on the ice; cover it with straw and they will keep well. The cocoons intended for reeling are put in the sun as soon as they are gathered; spread them thin, and a few days will kill the chrysalis. They must be well dried or they will mould. The pea-nut being much firmer and heavier, takes longer to kill and dry than any other variety. To sum up the whole: have good, well-kept eggs; give them plenty of room (an ounce of eggs, when the worms are full grown, should have twenty-five frames, three by four feet, to feed and wind on).

This is very essential. Keep them clean; feed in an open building; close it only when it is very windy. Cultivate your *trees* well; if they are not thrifty the worms will not be; yellow leaves will not do. Feed the worms all they will eat from the start. It is better to have them leave some, than not have enough. Have a good place for them to wind in; and if the weather is warm and uniform, the worms will do *their* part. If any are diseased, pick them off.

After the worm has enveloped itself in the cocoon, seven or eight days are permitted to elapse before the balls are gathered; the next process is to destroy the life of the chrysalides, which is done either by exposure to the sun, or by the heat of an oven or of steam. The cocoons are next separated from the floss, or loose downy substance, which envelopes the compact balls, and are then ready to be reeled. For this purpose, they are thrown into a boiler of hot water, for the purpose of dissolving the gum, and, being gently dressed with a brush, to which the threads adhere, the reeler is thus enabled to disengage them. The ends of four or more of the threads thus cleared are passed through holes in an iron bar, after which two of these compound threads are twisted together, and made fast to the reel. The length of reeled silk, obtained from a single cocoon, varies from 300 to 600 yards; and it has been estimated, that 12 lbs. of cocoons, the produce of the labors of 2,800 worms, who have consumed 152 lbs. of mulberry-leaves, give 1 lb. of reeled silk, which may be converted into 16 yards of gros de Naples.

Those cocoons which have been perforated cannot be reeled, but must be spun, on account of the breaks in the thread. The produce of these balls, when worked, is called *fleuret.*

Reeling is a branch of the silk business, which more properly comes under the head of manufacturing. Every farmer who engages in the silk culture, in order to avail himself of an additional profit, should provide his family with a suitable reel, by the use of which, after a little experience, he will be enabled to offer his silk in market, in a form that will greatly enhance its value, and much reduce the trouble and expense of transportation. Reels can now be procured in almost any of the principal cities at a small cost, or they can be made by any ingenious farmer or carpenter. The reel now uniformly used, is that known as the Piedmontese.

All attempts to improve this reel in its general principles, have failed. At Economy, however, they have made an addition which may be found useful. It consists of *two pair* of whirls, made of wire, in the form of an aspel to a reel, about *four* inches long and two and a half inches across at the ends, the wires being bent in the middle, leaving them about one and a half inches across from arm to arm, making the circumference about six inches. These whirls are set in an iron frame, and run *each* upon two points or centres. Each pair is set equidistant, on a direct line, about eight inches apart, between the first guides and those on the traverse bar, instead of making the usual number of turns around each thread, as they pass between the guides on the reel. With this arrangement, each thread is taken from the basin and passed through the first guides, then carried *over and around* the two whirls, and where they *pass* each other *on the top*, the *turns* are made necessary to give firmness to the thread, then passing directly through the guides in the traverse bar to the arms of the reel, making each thread in reeling independent of the other. This enables the reeler, when a remnant of cocoons are to be finished on leaving the work, to unite both threads into one, retaining the necessary size; whereas both would be too fine if continued on the reel in the ordinary manner.

Directions for reeling.—In family establishments, a common clay or iron furnace should be procured, to which should be fitted a sheet-iron top, about twelve inches high, with a door on one side, and a small pipe on the opposite side to convey off the smoke; this top should retain the same bevel or flare as the furnace, so as to be about twenty inches in diameter at the top. The pan should be twenty inches square and six inches deep, divided into four apartments, two of which should be one inch larger one way than the other. They should all communicate with each other at the bottom.

In large filiatures, a small steam engine to propel the reels, &c., and to heat the water for reeling would be necessary.

Before the operation of reeling is commenced, the cocoons must be stripped of their floss, and assorted into three separate parcels, according to quality, or of different degrees of firmness. The double cocoons or those formed by two or more worms spinning together, the fibres crossing each other and rendering them difficult to reel; these should be laid aside to be manufactured in a different manner.

After the cocoons have been assorted as above directed, the operation of reeling may be commenced. The basin should be nearly filled with the *softest* water, and kept to a proper heat by burning charcoal, or some other convenient method of keeping up a regular heat. The precise temperature cannot be ascertained until the reeling is commenced, owing to the different qualities of cocoons; those of the best quality will require a greater degree of heat than those of a more loose and open texture; hence the importance of assisting them. Cocoons also require less heat, and reel much better, when done before the chrysalides are killed, and the cocoons become dried.

The heat of the water may be raised to *near* the boiling point, (it should never be allowed to boil,) when two or three handfuls of cocoons may be thrown into one of the large apartments of the basin, which must be gently pressed under water for a few minutes, with a little brush, made of broom-corn, with the ends shortened. The heat of the water will soon soften the gum of the silk, and thereby loosen the ends of the filaments; the reeler should then gently stir the cocoons with the brush, until the loose fibres adhere to it; they are then separated from the brush, holding the filaments in the left hand, while the cocoons are carefully combed down between the fingers of the right hand, as they are raised out of the water. This is continued until the floss or false ends are all drawn off, and the fine silk begins to appear; the fibres are then broken off and laid over the edge of the basin. The floss is then cleared from the brush and laid aside as refuse silk, and the operation continued until most of the ends are thus collected.

If the silk is designed for sewings, about twenty-five fibres should compose a thread; if intended for other fabrics, from eight to fifteen should be reeled together. The finer silk should always be reeled from the best cocoons. The cocoons composing the threads are taken up in a small tin skimmer, made for the purpose, and passed from the large apartment of the basin to those directly under the guides. As the ends become broken they are passed back into the spare apartment, where they are again collected to be returned to the reel. The requisite number of fibres thus collected for *two* threads are passed, each, through the lower guides. They are then wound around each other two or three times, and each carried through the two guides in the traverse bar, and then attached to the arms of the reel. The turning should now be commenced with a slow and steady motion, until the threads run freely. While the reel is turning, the person attending the cocoons must continually be adding fresh ends, as they may be required, not waiting until the number she began with is reduced, because the internal fibres are much finer than those composing the external layers. In adding new ends, the reeler must attach them, by gently pressing them, with a little turn between the thumb and finger, to the threads as they are running. As the silk is reeled off, the chrysalides should be taken out of the basin, otherwise they obscure and thicken the water and injure the color and lustre of the silk. When the water becomes discolored, it should always be changed.

If, in reeling, the silk leaves the cocoon in burs or bunches, it is evident the water is too hot; or when the ends cannot be easily collected with the brush, or, when found, do not run freely, the water is too cold.

A pail of cold water should always be at hand, to be added to the basin as it may be required. When the cocoons yield their fibres freely, the reel may be turned with a quicker motion. The quicker the motion, the smoother and better will be the silk. When from four to six ounces have been reeled, the aspel may be taken off, that the silk may dry. The end should be fastened so as to be readily found. Squeeze the silk together and loosen it upon the bars; then on the opposite side tie it with a band of refuse silk or yarn, then slide it off the reel, double, and again tie it near each exremity.

The *quality* of the silk depends much upon the art and skilful management of the reeler. All that is required to render one perfect in the art of reeling, is a little *practice*, accompanied at the beginning with a degree of *patience*, and the exercise of *judgment* in keeping up the proper temperature of water, and the threads of a uniform size.

Manufacture of perforated cocoons.—The perforated and double cocoons can be manufactured into various fabrics—such as stockings, gloves, under-shirts, and the like. Before the cocoons can be spun, they must be put into a clean bag, made of some open cloth, and placed in a pot or kettle, and *covered* with soft water, with soap (hard or soft) added, sufficient to make a strong suds, and boiled for about three or four hours. If they are required to be very nice and white, the water may be changed, and a small quantity more of soap added, and again boiled for a few minutes. After they are boiled, they may be hung up and drained; they should then be rinsed while in the bag, in fair water, and hung out to dry, without disturbing them in the bag. When completely dry, they may be spun on the common flax wheel, by first taking the cocoon in the fingers, and *slightly* loosening the fibres that become flattened down by boiling, and then spinning off from the *pierced end*. The silk will run entirely off, leaving the shell bare.

The double cocoons may be spun in the same manner, but should be boiled separately.

SILK MANUFACTURE. This may be divided into two branches:—1, the production of raw silk; 2, its filature and preparation in the mill, for the purposes of the weaver and other textile artisans. The threads, as spun by the silk-worm, and wound up in its cocoon, are all twins, in consequence of the twin orifice in the nose of the insect through which they are projected. These two threads are laid parallel to each other, and are glued more or less evenly together by a kind of glossy varnish, which also envelopes them, constituting nearly 25 per cent. of their weight. Each ultimate filament measures about $\frac{1}{2000}$ of an inch in average fine silk, and the pair measures of course fully $\frac{1}{1000}$ of an inch.

The raw silk, before it can be used in weaving, must be twisted or thrown, and may be converted into shingles, tram, or organzine. The *first* is produced merely by twisting the raw silk, to give more firmness to its texture. *Tram* is formed by twisting together, but not very closely, two or more threads of raw silk, and usually constitutes the weft or shoot of manufactured goods. *Organzine* is principally used in the warp, and is formed by twisting, first, each individual thread, and then two or more of the threads, thus twisted, with the throwing-mill. The silk, when *thrown*, is called *hard silk*, and must be boiled, in order to discharge the gum, which, otherwise, renders it harsh to the touch, and unfit to receive the dye. After boiling about four hours in soaped water, it is washed in clear water, to discharge the soap, and is seen to have acquired that glossiness and softness of texture which forms its principal characteristic. The yarn is now ready for weaving.

Silk-worms are fed, in France, on the leaves of the white mulberry, planted in hedge-rows, as pollards, and raised from seeds by nurserymen. The eggs are hatched in rooms, heated to 72½° F. One ounce of eggs consume 1 cwt. of leaves, and produce from 7 to 9 lbs. of raw silk, which is wound off the cocoons by women and children. The season is May.

The silk-worm is now propagated in the United States, and even so far north as 45° there is a mulberry-orchard of 100 acres, and considerable produce of silk, 8½ dollars per lb.

Silk-worms may be reared with success on the leaves of the scorsonera, or with acer tartarium.

Satin is a silk twill of peculiar description, the soft and lustrous face of which is given by keeping a large proportion of the threads of the warp visible. When first taken out of the loom, satins are sometimes flossy and rough; and they are dressed by being rolled on heated cylinders, which operation gives the brilliant lustre.

Watering silk is performed by passing two pieces of silk placed lengthways, one on the other, between two metallic rollers: the different parts are thus subjected to different degrees of pressure, from which the wavy appearance results.

Silk is *embossed* by passing the plain stuff between rollers; the surfaces of which contain the desired pattern on one cylinder, and on the other sunk, so that the eminences of the one coincide with the depressions of the other.

This business, like all other branches of manufacturing industry, has struggled, in this country, against adverse fortune, and counteracted difficulties not contemplated by its early founders. But we believe for the past year or two the manufacture of sewing silk has been highly prosperous, and several new mills have been erected in different sections of the country. In Tolland county, Conn., there are six factories, which respectively turn off the following amounts of sewing silk and twist per annum:—

Vyse & Sons,	at Willington,.....	12,000	pounds.
Rixford & Butler,	at Mansfield,...	5,000	"
William Atwood,	" ...	3,700	"
Zalmon, Storrs & Son,	" ...	2,000	"
J. & E. Hovey,	" ...	1,500	"
Chaffee & Co.,	" ...	1,000	"

In addition to these, we will enumerate the remaining establishments which we know to be in operation in different sections of the United States, with a probably correct estimate of the amount of goods manufactured per annum:—

Cheney & Brothers, Manchester, Conn.,.........................	16,000	pounds.
A. B. Jones, do. do.,.............	2,500	"
Sowerby & Co., Northampton, Mass ,.........................	7,000	"
Joseph Conant, do. do.,...........	3.500	"
———— ————, New Haven, Conn.,	1.500	"
William Dale, New York city,...	2,500	"
Murray & Co., Patterson, N. J.,...	10,000	"
Livesy & Co., Canton, Mass......	2,000	"
B. & A. Hooley, Philadelphia,...	3,000	"
Brown & Co., Louisville, Ky.,...	1,500	"

SILVER. When pure and planished, silver is the brightest of the metals. Its specific gravity in the ingot is 10·47; but, when condensed under the hammer or in the coining press, it becomes 10·6. It melts at a bright red heat, a temperature estimated by some as equal to 1280° Fahr., and by others to 22° Wedgewood. It is exceedingly malleable and ductile; affording leaves not more than $\frac{1}{100000}$ of an inch thick, and wire far finer than a human hair.

Its tenacity is, to that of gold and platinum, as the numbers 19, 15, and 26¼; so that it has an intermediate strength between these two metals. Pure atmospheric air does not affect silver, but that of houses impregnated with sulphureted hydrogen, soon tarnishes it with a film of brown sulphuret. It is distinguished chemically from gold and platinum by its ready solubility in nitric acid, and from almost all other metals, by its saline solutions affording a curdy precipitate with a most minute quantity of sea salt, or any soluble chloride.

Silver occurs under many forms in nature:—

1. *Native silver* possesses the greater part of the above properties; yet, on account of its being more or less alloyed with other metals, it differs a little in malleability, lustre, density, &c. It occurs crystallized in wedge-form octahedrons, in cubes, and cubo-octahedrons; or in dendritic shapes, and arborescences, resulting from minute crystals implanted upon each other. But more usually it presents itself in small grains without determinable form, or in amorphous masses of various magnitude.

The *gangues* (mineral matrices) of native silver are so numerous, that it may be said to occur in all kinds of rocks. At one time it appears as if filtered into their fissures, at another as having vegetated on their surface, and at a third, as if impasted in their substance. Such varieties are met with principally in the mines of Peru and Mexico.

The native metal is found in almost all the silver mines now worked; but especially in that of Kongsberg in Norway; at Schlangenberg in Siberia, in a sulphate of barytes; at Allémont, in a ferruginous clay, &c.

The metals most usually associated with silver in the native alloy are gold, copper, arsenic, and iron. At Andreasberg and Guadalcanal it is alloyed with about 5 per cent. of arsenic. The auriferous native silver is the rarest; it has a brass-yellow color.

2. *Antimonial silver.*—This rare ore is yellowish-blue; destitute of malleability; even very brittle; spec. grav. 9·5. It melts before the blowpipe, and affords white plumes of oxide of antimony. It

consists of from 76 to 84 of silver, and from 24 to 16 of antimony.

3. *Mixed antimonial silver.*—At the blowpipe it emits a garlic smell. Its constituents are, silver 16, iron 44, arsenic 35, antimony 4. It occurs at Andreasberg.

4. *Sulphuret of silver.*—This is an opaque substance, of a dark-gray or leaden hue; slightly malleable, and easily cut with a knife, when it betrays a metallic lustre. The silver is easily separated by the blowpipe. It consists of, 13 of sulphur to 89 of silver, by experiment. Its spec. grav. is 6·9. It occurs crystallized in most silver mines, but especially in those of Freyberg, Bohemia, Schemnitzin, Hungary, and Mexico.

5. *Red sulphuret of silver; silver glance.*—Its spec. grav. is 5·7. It contains from 84 to 86 of silver.

6. *Sulphuretted silver, with bismuth.*—Its constituents are lead 35, bismuth 27, silver 15, sulphur 16, with a little iron and copper. It is rare.

7. *Antimoniated sulphuret of silver*, the red silver of many mineralogists, is an ore remarkable for its lustre, color, and the variety of its forms. It is friable, easily scraped by the knife, and affords a powder of a lively crimson red. Its color in mass is brilliant red, dark red, or even metallic reddish-black. It crystallizes in a variety of forms. Its constituents are—silver from 56 to 62; antimony from 16 to 20; sulphur from 11 to 14; and oxygen from 8 to 10. The antimony, in the state of a purple oxide in this ore, is its coloring principle. It is found in the mines of Freyberg, Sainte-Marie-aux-Mines, and Guadalcanal.

8. *Black sulphuret of silver*, is blackish, brittle, cellular, affording globules of silver at the blowpipe. It is found abundantly in the silver mines of Peru and Mexico. The Spaniards call it *negrillo.*

9. *Chloride of silver, or horn silver.*—In consequence of its semi-transparent aspect, its yellowish or greenish color, and such softness that it may be cut with the nail, this ore has been compared to horn, and may be easily recognized. It melts at the flame of a candle, and may be reduced when heated along with iron or black flux, which are distinctive characters. It is seldom crystallized; but occurs chiefly in irregular forms, sometimes covering the native silver as with a thick crust, as in Peru and Mexico. Its density is only 4·74.

General treatment of silver ores.—All ores which contain more than 7 lbs. of lead, or 1 lb. of copper, per cent., are excluded from the reviving operation, or amalgamation; because the lead would render the amalgam very impure, and the copper would be wasted. They are sorted for the amalgamation, in such a way, that the mixture of the poorer and richer ores may contain 4 oz. of silver per 100 lbs. The most usual constituents of the ores are, sulphur, silver, antimonial silver, bismuth, sulphurets of arsenic, of copper, iron, lead (nickel, cobalt), zinc, with several earthy minerals. It is essential that the ores to be amalgamated shall contain a certain proportion of sulphur, in order that they may decompose enough of sea salt in the roasting to disengage as much chlorine as to convert all the silver present into a chloride. With this view, ores poor in sulphur are mixed with those that are richer, to make up a determinate average. The ore-post is laid upon the *bed-floor*, in a rectangular heap, about 17 ells long, and 4½ ells broad (18 yards and 3½); and upon that layer the requisite quantity of salt is let down from the floor above, through a wooden tunnel; 40 cwts. of salt being allotted to 400 cwts. of ore. The heap being made up with alternate strata to the desired magnitude, must be then well mixed, and formed into small bings, called *roast-posts*, weighing each from 8½ to 4½ cwts.

Roasting of the amalgamation ores.—The furnaces appropriated to the roasting ore-posts are of the reverberatory class, provided with soot chambers. The prepared ground ore is spread out upon the hearth, and dried with incessant turning over; then the fire is raised so as to kindle the sulphur, and keep the ore redhot for one or two hours; during which time, dense white-gray vapors of arsenic, antimony, and water, are exhaled. The desulphuration next begins, with the appearance of a blue flame. This continues for three hours, during which the ignition is kept up. Whenever sulphurous acid ceases to be formed, the finishing calcination is to be commenced with increased firing; the object being now to decompose the sea salt by means of the metallic sulphates that have been generated, to convert them into chlorides, with the simultaneous production of sulphate of soda. The stirring is to be continued till the proofs taken from the hearth no longer betray the smell of sulphurous, but only of muriatic acid gas. Out of the *nicht* chambers or soot vaults of the furnaces, from 96 to 100 cwts. of ore-dust are obtained, containing 16 lbs. of silver. This dust is to be treated like unroasted ore. The fuel of the first fire is pitcoal; of the finishing one, fir-wood. Of the former 115¼ cubic feet, and of the latter, 294½, are, upon an average, consumed for every 100 cwts. of ore.

During the last roasting, the ore increases in bulk by one-fourth, becomes in consequence a lighter powder, and of a brown color. When this process is completed, the ore is raked out upon the stone pavement, allowed to cool, then screened in close sieve-boxes, in order to separate the finer powder from the lumps. These are to be bruised, mixed with sea salt, and subjected to another calcination. The finer powder alone is taken to the millstones. The stones are of granite, and make from 100 to 120 revolutions per minute. The roasted ore, after it has passed through the bolter of the mill, must be as impalpable as the finest flour.

The amalgamation.—This is performed in horizontal casks, arranged in rows, each turning upon a shaft which passes through its axis; and all driven by water-wheels. The casks are 2 feet 10 inches long, 2 feet 8 inches wide, inside measure, and are provided with iron ends. The staves are 3¼ inches thick, and are bound together with iron hoops. They have a double bung-hole, one formed within the other, secured by an iron plug fastened with screws. They are filled by means of a wooden spout terminated by a canvass hose; through which 10 cwts. of the bolted ore-flour are introduced after 3 cwts. of water have been poured in. To this mixture, from ¾ to ⅝ of a cwt. of pieces of iron, 1¼ inch square, and ⅜ thick. When these pieces get dissolved, they are replaced by others from time to time. The casks being two-thirds full, are set to revolve from 1½ or 2 hours, till the ore-powder and water become a uniform pap; when 5 cwts. of quicksilver are poured into each of them. The casks being again made tight, are put in gear with the driving machinery, and kept constantly revolving for 14 or 16 hours, at the rate of 20 or 22 turns in the minute. During this time they are twice stopped and opened, in order to see whether the pap be of the proper consistence; for if too thick, the globules of quicksilver do not readily combine with the particles of ore; and if too thin, they fall and rest at the bottom. In the first case, some water must be added; in the second, some ore. During the rotation, the temperature rises, so that even in winter it sometimes stands so high as 104° F.

The chemical changes which occur in the casks are the following:—The metallic chlorides present in the roasted ore are decomposed by the iron, whence results muriate of iron, whilst the deutochloride of copper is reduced partly to protochloride, and partly to metallic copper, which throw down metallic silver. The mercury dissolves the silver, copper, lead, antimony, into a complex amalgam. If the iron is not present in sufficient quantity, or if it has not been worked with the ore long enough to convert the copper deutochloride into a protochloride, previously to the addition of the mercury, more or less of the last metal will be wasted by its conversion into protochloride (calomel). The water holds in solution sulphate of soda, undecomposed sea salt, with chlorides of iron, manganese, &c.

From 300 lbs. of amalgam 7 lbs. of impure silver mass is obtained, which yields from 10 to 13 parts out of 16 of pure silver—one-fifth being copper. The crude silver is refined in blacklead crucibles, filled within 2 inches of their brims, and exposed to a high heat. The mass gives off vapors, and throws up a liquid slag, which being skimmed off, the surface is to be strewed over with charcoal powder, and covered with a lid. The heat having been briskly urged for a short time, the charcoal is then removed along with any fresh slag that may have risen, in order to observe whether the vapors have ceased. If not, fresh charcoal must be again applied, the crucible must be covered, and the heat increased, till fumes are no longer produced, and the surface of the silver becomes tranquil. Finally, the alloy, which contains a little gold and much copper, being now from 11 to 13 parts of fine silver in 16 parts, is cast into iron moulds, in ingots of 60 marcs. The loss of weight by evaporation and skimming of the slag amounts to 2 per cent.; the loss in silver is quite inconsiderable.

In Mexico a new process has been introduced which dispenses with amalgamation. The ore is converted into a chloride by common salt, which chloride is then dissolved by a solution of salt. Copper slips are thrown into the liquor, which separate the silver by precipitation.

Dr. Percy, of England, proposes to separate the silver from the ore by the wet way, using hyposulphite and chloride of lime: the process is recommended as economical.

Till very recently, the only operations employed for separating silver from lead in the English smelting-works, were the following:—

1. Cupellation, in which the lead was converted into a vitreus oxide, which was floated off from the surface of the silver.
2. Reduction of that oxide, commonly called litharge.
3. Smelting the bottoms of the cupels, to extract the lead which had soaked into them, in a glassy state.

Cupellation and its two complementary operations were, in many respects, objectionable processes; from the injurious effects of the lead vapors upon the health of the workmen; from the very considerable loss of metallic lead, amounting to 7 per cent. at least; and, lastly, from the immense consumption of fuel, as well as from the vast amount of manual labor incurred in such complicated operations. Hence, unless the lead were tolerably rich in silver, it would not bear the expense of cupellation.

The patent process lately introduced by Mr. Pattison, of Newcastle, is not at all prejudicial to the health of workmen; it does not occasion 2 per cent. of loss of lead, and in other respects is so economical, that it is now profitably applied in Nothumberland to alloys too poor in silver to be treated by cupellation. This process is founded on the following phenomena.

After melting completely an alloy of lead and silver, if we allow it to cool very slowly, continually stirring it meanwhile with a rake, we shall observe at a certain period a continually increasing number of imperfect little crystals, which may be taken out with a drainer, exactly as we may remove the crystals of sea salt deposited during the concentration of brine, or those of sulphate of soda, as its agitated solution cools. On submitting to analysis the metallic crystals thus separated, and also the liquid metal deprived of them, we find the former to be lead almost alone, but the latter to be rich in silver, when compared with the original alloy. The more of the crystalline particles are drained from the metallic bath, the richer does the *mother* liquid become in silver. In practice, the poor lead is raised by this means to the standard of the ordinary lead of the litharge works; and the better lead is made ten times richer. This very valuable alloy is then submitted to cupellation; but as it contains only a tenth part of the quantity of lead subjected to crystallization, the loss in the cupel will be obviously reduced to one-tenth of what it was by the former process; that is, seven-tenths of a per cent. instead of seven.

Mr. Johnson proposes to treat the alloy first with acetic acid to lessen the quantity of lead, and then either melt it or subject it to cupellation.

The treatment of the compound ores of silver is usually accomplished either by roasting or amalgamation. A considerable quantity of silver is obtained from argentiferous galena. In fact, almost every specimen of native sulphuret of lead will be found to contain traces of this metal. When the proportion rises to a certain amount it is worth extracting. The ore is reduced in the usual manner, the whole of the silver remaining with the lead; the latter is then remelted in a large vessel, and slowly allowed to cool until solidification commences; the portion which first crystallizes is nearly pure lead, the alloy with silver being more fusible than lead itself. By particular management this is drained away, and is found to contain nearly the whole of the silver. This rich mass is next exposed to a red heat on the shallow hearth of a furnace, while the stream of air is allowed to infringe upon its surface. Oxidation takes place with great rapidity: the fused oxide, or *litharge*, being constantly swept from the metal by the blast. When the greater part of the lead has been thus removed, the residue is transferred to shallow dishes made of bone ash, and again heated. The last of the lead is now oxidated, and the oxide sinks in a melted state into the porous vessel, while the silver, almost chemically pure and having a brilliant surface, remains behind. (*See* CUPELLATION.)

When silver is melted in open vessels it has the curious property of absorbing oxygen, which it gives out when it congeals. This is the cause of the appearance of granular crystallization which silver assumes when hastily cooled: a small *per centage* of copper entirely prevents the effect. The only pure acids which act upon silver are the nitric and sulphuric. The nitric acid dissolves silver without the aid of heat, nitrous gas is evolved, and a dense colorless solution obtained, from which tabular crystals of nitrate of silver may be produced by evaporation. These crystals are anhydrous, and consist of 118 oxide of silver and 54 nitric acid, the equivalent of silver being 110. When melted, and cast into sticks or quills, they form the *lunar caustic* of the surgeons.

Chloride of silver is readily made by adding common salt to a solution of nitrate of silver. It is a white curdy powder which becomes violet when exposed to sunshine, and is soluble in water of ammonia and alkaline hyposulphites.

SILVERING. The covering the surface of metal, or other body, with a bright coating of silver. (*See* PLATE, MANUFACTURE OF.)

The dial-plates of clocks, the scales of barometers, and other similar articles, are silvered by rubbing upon them a mixture of muriate of silver, sea-salt, and tartar, and afterwards washing off the saline matter with water. In this operation, the silver is precipitated from the muriatic acid, which unites with part of the coppery surface. *Silvering of pins* is effected by boiling them with tin filings and tartar.

To make shell-silver, silver-leaf is ground with gum-water, or honey: the gum, or honey, is washed away, and the powder which remains is used with gum-water, or white of eggs, laid on with a hair-pencil.

Silvering for looking-glasses.—Looking-glasses are silvered by an extemporaneous amalgamation of tin and quicksilver. Tin-foil is placed on the back of the glass, and some quicksilver is poured upon it, and spread over the surface with a hare's foot. Another glass is then slid over the tin, to drive off part of the quicksilver; and paper and a board being laid on the tin, it is strongly pressed with a number of weights, to expel, by degrees, the superfluous quicksilver, and leave only a crystallized amalgam on the back of the glass.

Mr. Drayton, some years back, invented a new mode of silvering, by using a solution of nitrate of silver in ammonia, and then adding a small quantity of essential oil, as that of cloves, cajeput, &c. By applying gentle heat, in a short time the silver is reduced in a beautiful bright mirror upon the surface of the glass; if the latter surface be flat, walls of putty are necessary. Deep vessels can have the solution poured in and allowed to lay till deposition takes place.

Silvering for globes.—This amalgam is made by dissolving one pound of tin, glass, or bismuth, in four pounds of quicksilver. The globes to be silvered are thoroughly cleaned on the inside, and warmed; then the above amalgam being heated, so as to be perfectly liquid, is poured in by a paper funnel, and the globe inclined in various directions, that, as the amalgam crystallizes by cooling, it may adhere to all parts of the globe; the superfluous amalgam is then poured out.

Silvering ivory.—Immerse a slip of ivory in a weak solution of nitrate of silver, and let it remain till the solution has given it a deep yellow color: then take it out and immerse it in a tumbler of clear water, and expose it in water to the rays of the sun. In about three hours the ivory acquires a black color, but the black surface, on being rubbed, is soon changed to a brilliant silver.

Silvering Daguerreotype plates.—Precipitate oxide of silver from the nitrate by potass; filter, wash, and dry it. Dissolve this oxide in pure liquid ammonia, the solution will be of a yellow color. Immerse a slip of polished copper in it, and let the moisture evaporate. When the copper is quite dry, hold it over a charcoal fire; the oxide will be decomposed, and the metal reduced on the copper in the form of a complete coating. This may be made beautifully bright by polishing with leather. It offers a much more brilliant and smooth surface than that of the last experiment, and is a ready method of silvering copper-plates for the Daguerreotype pictures. It is not, however, equally well performed as by the galvanic process. (*See* ELECTRO METALLURGY.)

SKEW BRIDGE. In engineering, the name given to a kind of bridge introduced upon railroads, when the railway intersects any existing communication at right angles. Such bridges were occasionally built before railroads were introduced; but their general introduction has rendered the use of skew bridges universal in cases where it may be necessary or unavoidable to preserve as straight or direct a line as possible.

SLATES. The substances belonging to this class may be distributed into the following species:—

1. Mica-slate, occasionally used for covering houses.
2. Clay-slate, the proper roofing-slate.
3. Whet-slate.
4. Polishing-slate.
5. Drawing-slate, or black chalk.
6. Adhesive slate.
7. Bituminous shale.
8. Slate-clay.

Mica-slate.—This is a mountain rock of vast continuity and extent, of a schistose texture, composed of the minerals mica and quartz, the mica being generally predominant.

Clay-slate.—This substance is closely connected with mica; so that uninterrupted transitions may be found between these two rocks in many mountain chains. It is a simple schistose mass, of a bluish-gray, or grayish-black color, of various shades, and a shining, somewhat pearly internal lustre on the faces, but of a dead color in the cross fracture.

All the best beds of roofing-slate improve in quality as they lie deeper under the surface; near to which, indeed, they have little value.

A good roofing slate should split readily into thin even laminæ; it should not be absorbent of water either on its face or endwise, a property evinced by its not increasing perceptibly in weight after immersion in water; and it should be sound, compact, and not apt to disintegrate.

Some of the first qualities of slate for roofing, are now found in Vermont, near Brattleboro'. It equals the Welsh, and somewhat resembles it. It is also found in Worcester co., Harvard, and Pepperel, Mass. It occurs over a large tract in N. Carolina. We see by Arkansas papers that a valuable quarry of it has just been discovered in Eagle Town, in the Choctaw country. The slate is in two hills, about a hundred feet high, which, it is said, are composed wholly of slate.

Slates for roofs, are trimmed, shaped, and bored by the slater. The roof is boarded with feather-edged weather-boards, and the slates are fixed with copper or zinc nails. A roof should incline from 12° to 25°. The best slate is bluish-gray; light-gray is stony and does not shape easily; black or dark absorbs wet, and quickly decays. They are for roofs, from 15 inches by 8. to 3 feet by 2 feet. The Welsh, Switzerland, and Kendal, are the best and largest.

It is also found in the vicinity of Boston, at Charleston, Quincy, and Meldon. Tulcore and chlorite slates are found in the New England states abundantly. These are the gangue of the gold in the southern states. Drawing-slates are found in Rhode Island.

SLEEPER. In architecture, a piece of timber whereon are laid the ground joists of a floor. *Sleepers* are also pieces of timber, now rarely used, in foundations crossed by planks, &c., and at right angles to them, where the soil is bad. Formerly the term was used to denote the valley rafters of a roof.

SMALT. A fine blue color used in painting and printing upon earthenware, and applied to several other purposes in the arts. The finest smalt is made by fusing glass with oxide of cobalt, by which a very deep blue compound is obtained, which, when finely powdered, acquires a beautiful azure color. Common smalts are prepared by fusing mixtures of zaffre, sand, and pearlash.

SMARAGD. In modern times used as a synonym of emerald (which see); but applied by the ancients to various other precious stones, such as fluor spar, green vitrified lava, green jasper, and green glass. The smaragd is found in various parts of Europe, Asia, and America; but particularly in the Ural mountains, and in the mines of Chili and Mexico.

SMELLING SALTS are usually either pure ammonia or its carbonate. Take a small piece of burnt unslaked lime, say 1¼ oz., and add to it in a mortar 1 oz. of muriate of ammonia, rub them well together, and the pungent smell of ammoniacal gas will be given off; then bottle, perfume it, and cork. The chlorine of the sal-ammoniac has a greater affinity for lime than ammonia, it therefore leaves the ammonia and combines with the lime, forming the chloride of calcium, whilst the ammoniacal gas is set at liberty.

SOAP. This useful compound is obtained by the action of alkalies upon oily substances. There are, accordingly, a great variety of soaps; but those commonly employed may be considered under the heads of—1, fine white soaps, scented soap, &c.; 2, coarse household soaps; 3, soft soaps. The materials used in the manufacture of white soaps are generally olive oil and carbonate of soda: the latter is rendered caustic by the operation of quicklime, and the solution thus obtained is called *soap ley*. The oil and a weak ley are first boiled together, and portions of stronger ley are gradually added, till the soap, produced by the mutual action of the oil and alkali, begins to become tenacious, and to separate from the water; some common salt is then generally added to promote the granulation and perfect separation of the soap: the fire is then drawn, and the contents of the boiler allowed to remain for some hours at rest, so that the soap may more completely collect. When it is perfect it is put into wooden frames or moulds; and when stiff enough to be handled, it is cut into oblong slices and dried in an airy room. Perfumes are occasionally added, or various coloring matters stirred in while the soap is semifluid to give it a mottled appearance. The Spanish soap is *marbled* by stirring into it a solution of sulphate of iron, which is decomposed by the soap, and black oxide of iron separated in streaks and patches through the mass. The action of the air converts the exterior into red oxide, while the interior long retains its black color; hence a slice of this soap presents a black mottled centre, surrounded by a reddened external layer.

Common household soaps are made chiefly of soda and tallow; or if potash is used, a large addition of common salt is made to harden the soap, which it probably effects by the transference of soda. Yellow soap has a portion of resin added to it. Soft soaps are generally made with potash instead of soda, and fish oil: it has a tenacious consistence, and appears granulated. Soap is soluble in pure water and in alcohol; the latter solution *jellies* when concentrated, and is medicinally known under the name of *opodeldoc*. When carefully evaporated the soap remains in a gelatinous state, which forms, when dry, the article sold under the name of *transparent soap*.

The earths and common metallic oxides form *insoluble soaps;* and accordingly these are precipitated when earthy and metallic salts are added to solution of soap. It is the sulphate of lime and carbonate of lime in common spring water which thus render it unfit for washing, and give it what is termed *hardness;* and, upon this principle, a spirituous solution of soap is a simple and valuable test of the fitness of any river or spring water for the purposes of the laundry. If it merely renders the water slightly opalescent, as is the case with rain and other soft waters, it may be used for washing; but if it become milky, it is usually too hard to be conveniently employed; and when one washes the skin with hard water, the separation of the insoluble calcareous soap is extremely disagreeable; it adheres to the skin, and soils instead of cleansing it.

The chemical nature of soap has been laboriously examined by Chevreul, who has shown that the alkali in the process of saponification converts the oil into peculiar *acids*, as he terms them; the elain of the oil forming *oleic acid*, and the stearine *margaric acid:* so tht soluble soaps are oleates and margarates of soda and potash. He has enumerated several other fatty acids similarly produced.

All new soaps contain a considerable portion of adhering water, a great part of which they lose when kept in a dry place; hence the economy and excellence of *old* soap; and hence the dealers in soap generally keep it in a damp cellar, that it may not lose weight by evaporation; or, as it is said, sometimes immerse it in brine, which does not dissolve it, but keeps it in its utmost state of humidity.

Soap may be considered as a necessary of life; in all civilized countries its consumption is immense. According to Pliny, the invention of soap must be ascribed to the Gauls, by whom, he says, it was composed of tallow and ashes, though the German soap was considered the best.

Liebig has forcibly observed that we may estimate the conditions of comfort and civilization of a nation by the quantity of soap which it consumes.

Of the manufacture of hard soap.—The fat of this soap is usually tallow or coarse olive oil. Different species of grease are saponified by soda, with different degrees of facility; among oils, the olive, sweet almond, rapeseed, and castor oil; and among solid fats, tallow, bone grease, and butter, are most easily saponified. From 12 to 13 cwts. of tallow are estimated to produce one ton of good soap. Some years ago, in many manufactories the tallow used to be saponified with potash leys, and the resulting soft soap was converted, in the course of the process, into hard soap, by the introduction of muriate of soda, or weak kelp leys, in sufficient quantity to furnish the proper quantity of soda by the reaction of the potash upon the neutral salts. But the high price of potash, and the diminished price as well as improved quality of the crude sodas, have led to their general adoption in soap-works. The soda-ash used by the soap-boiler, contains in general about 36 per cent. of real soda, in the state of dry carbonate, mixed with muriate of soda, and more or less undecomposed sulphate. The barillas from Spain and Teneriffe contain from 18 to 24 per cent. of real soda.

The crude soda being ground, is to be stratified with lime in cylindrical cast-iron vats, from 6 to 7 feet wide, and from 4 to 5 feet deep; the lowest layer consisting, of course, of unslaked or shell quicklime. The vats have a false bottom, perforated with holes, and a lateral tubulure under it, closed commonly with a wooden plug, similar to the *épine* of the French soap pans, by which the leys trickle off clear and caustic, after infiltration through the beds of lime. The quantity of lime must be proportional to the carbonic acid in the soda.

Upon 1 ton of tallow put into the soap pan, about 200 gallons of soda ley, of specific gravity 1·040, being poured, heat is applied, and after a very gentle ebullition of about 4 hours, the fat will be found to be completely saponified, by the test of the spatula, trowel, or pallet knife; for the fluid ley will be seen to separate at once upon the steel blade, from the soapy paste. Such leys, if composed of pure caustic soda, would contain 4 per cent. of alkali; but from the presence of neutro-saline matter, they seldom contain so much as 2 per cent.; in fact, a gallon may be estimated to contain not more than 2 ounces; so that 200 gallons contain 25 pounds of real soda. The fire being withdrawn from the soap-pan, the mass is allowed to cool during one hour, or a little more, after which the spent leys, which are not at all alkaline, are run off by a spigot below, or pumped off above, by a pump set into the pan. A second similar charge of ley is now introduced into the pan, and a similar boiling process is renewed. Three such boils may be given in the course of one day's work, by an active soap-maker. Next day the same routine is resumed with somewhat stronger leys, and so progressively, till, towards the sixth day, the ley may have the density of 1·160, and will be found to contain 6 per cent. of real soda. Were the ley a solution of pure caustic soda, it would contain at this density no less than 14½ per cent. of alkali. The neutro-saline matter present in the spent ley is essential to the proper granulation and separation of the saponaceous compound; for otherwise the watery menstruum would dilute and even liquefy the soap. Supposing 12½ cwts. of tallow to yield upon an average 20 cwts. of hard soap, then 20 cwts. of tallow will produce 32 cwts.

Of yellow or rosin soap.—Rosin, although very soluble in alkaline menstrua, is not however susceptible, like fats, of being transformed into an acid, and will not of course saponify, or form a proper soap by itself. The more caustic the alkali, the less consistence has the resinous compound which is made with it. Hence fat of some kind, in considerable proportion, must be used along with the rosin, the *minimum* being equal parts; and then the soap is far from being good. As alkaline matter cannot be neutralized by rosin, it preserves its peculiar acrimony in a soap poor in fat, and is ready to act too powerfully upon woollen and all other animal fibres to which it is applied. It is said that rancid tallow serves to mask the strong odor of rosin in soap, more than any oil or other species of fat. From what we have just said, it is obviously needless to make the rosin used for yellow soaps pass through all the stages of the saponifying process; nor would this indeed be proper, as a portion of the rosin would be carried away, and wasted with the spent leys. The best mode of proceeding, therefore, is first of all to make the hard soap in the usual manner, and at the last service or charge of ley, namely, when this ceases to be absorbed, and preserves in the boiling-pan its entire causticity, to add the proportion of rosin intended for the soap. In order to facilitate the solution of the rosin in the soap, it should be reduced to coarse powder, and well incorporated by stirring with the rake. The proportion of rosin is usually from one-third to one-fourth the weight of the tallow. The boil must be kept up for some time with an excess of caustic ley; and when the paste is found, on cooling a sample of it, to acquire a solid consistence, and when diffused in a little water, not to leave a resinous varnish on the skin, we may consider the soap to be finished. We next proceed to draw off the superfluous leys, and to purify the paste. For this purpose, a quantity of leys at 80° B. being poured in, the mass is heated, worked well with a rake, then allowed to settle, and drained of its leys. A second service of leys, at 4° B., is now introduced, and finally one at 2°; after each of which, there is the usual agitation and period of repose. The pan being now skimmed, and the scum removed for another operation, the soap is laded off by hand-pails into its frame-moulds. A little palm oil is usually employed in the manufacture of yellow soap, in order to correct the flavor of the rosin, and brighten the color. This soap, when well made, ought to be of a fine wax-yellow hue, be transparent upon the edges of the bars, dissolve readily in water, and afford, even with hard pump-water, an excellent lather.

The frame-moulds for hard soap are composed of strong wooden bars, made into the form of a parallelogram, which are piled over each other, and bound together by screwed iron rods, that pass down through them. A square well is thus formed, which in large soap factories is sometimes 10 feet deep, and capable of containing a couple of tons of soap.

Mr. Sheridan some time since obtained a patent for combining silicate of soda with hard soap, by triturating them together in the hot and pasty state with a crutch in an iron pan. In this way from 10 to 30 per cent. of the silicate may be introduced. Such soap possesses very powerful detergent qualities, but it is apt to feel hard and be somewhat gritty in use. The silicated soda is prepared by boiling ground flints in a strong caustic ley, till the specific gravity of the compound rises to nearly double the density of water. It then contains about 35 grains of silica, and 46 of soda-hydrate, in 100 grains.

Hard soap, after remaining two days in the frames, is at first divided horizontally into parallel tablets, 3 or 4 inches thick, by a brass wire; and these tablets are again cut vertically into oblong nearly square bars, called wedges in Scotland.

Dr. Ure examined several soaps, and found their composition somewhat different. For instance:—

The foreign Castile soap of the apothecary has a specific gravity of 1·0705, and consists of—

Soda	9
Oily fat	76·5
Water and coloring-matter	14·5
	100·0

A perfumer's white soap was found to consist of—

Soda	9
Fatty matter	75
Water	16
	100

A London cocoa-nut oil soap was found to consist of—

Soda	4·5
Cocoa-nut lard	22·0
Water	73·5
	100·0

This remarkable soap was sufficiently solid; but it dissolved in hot water with extreme facility. It is called marine soap, because it washes linen with sea water.

A poppy-nut oil hard soap consisted of—

Soda	7
Oil	76
Water	17
	100

Soft soap.—The principal difference between soaps with base of soda, and soaps with base of potash, depends upon their mode of combination with water. The former absorb a large quantity of it, and become solid; they are chemical hydrates. The others experience a much feebler cohesive attraction; but they retain much more water in a state of mere mixture. From its solubility, more alkaline reaction, and lower price, potash soap is preferred for many purposes, and especially for scouring woollen yarns and stuffs.

Soft soaps are usually made in this country and in England with whale, seal, olive, and linseed oils, and a certain quantity of tallow; on the continent of Europe, with the oils of hempseed, sesame, rapeseed, linseed, poppy-seed, and calza; or with mixtures of several of these oils. The potash leys should be made perfectly caustic, and of at least two different strengths; the weakest being of specific gravity 1·05; and the strongest, 1·20, or even 1·25. A portion of the oil being poured into the pan, and heated to nearly the boiling point of water, a certain quantity of the weaker ley is introduced; the fire being kept up so as to bring the mixture to a boiling state. Then some more oil and ley are added alternately, till the whole quantity of oil destined for the pan is introduced. The ebulition is kept up in the gentlest manner possible, and some stronger ley is occasionally added, till the workmen judge the saponification to be perfect. The boiling becomes progressively less tumultuous, the frothy mass subsides, the paste grows transparent, and gradually thickens. The operation is considered to be finished when the paste ceases to affect the tongue with an acrid pungency, when all milkiness and opacity disappear, and when a little of the soap placed to cool upon a glass-plate assumes the proper consistency.

The exports of American soap and tallow candles were for 1847 and 1848 respectively, of the value, in—

1847	$606,798
1849	$670,223

SOAPSTONE. (*See* STEATITE.)

SODA. Natron; mineral alkali. This important and useful substance is an oxide of sodium. Sodium was discovered by Davy in 1808. It is a metal much resembling potassium in its general characters. It is soft, malleable, fusible at 190°, and burns when heated in contact of air. When thrown upon water it does not burn, but floats about upon the surface, and rapidly disappears, being converted into soda, which is dissolved in the water, and gives it an alkaline reaction. The specific gravity of sodium is 0·97. By the quantity of hydrogen evolved during the action of sodium on water, we learn that soda, or oxide of sodium, consists of 1 equivalent of sodium=24, and 1 of oxygen=8. The equivalent of soda, therefore, is 32. The commercial demands for soda are chiefly supplied from two sources: the combustion of marine vegetables, such as common sea-weed and the *salsola soda*, which furnish the impure alkalies called *kelp* and *barilla;* and the decomposition of common salt, or, rather, perhaps, of sulphate of soda, obtained by the decomposition of salt by sulphuric acid. Carbonate of soda forms large rhombo-prismatic crystals, composed of 32 soda + 22 carbonic acid + 90 water. They fuse in their water of crystallization at about 150°, and it may be entirely expelled by exposure to heat. They effloresce when exposed to air. Sulphate of soda, or Glauber's salt, is the result of the action of sulphuric acid upon common salt (*see* Muriatic Acid.) It consists of 32 soda + 40 sulphuric acid; and the crystals are constituted of 72 dry sulphate and 90 water: they are efflorescent, and soluble in about three parts of cold water. When sodium is introduced into chlorine, it immediately combines with it to form chloride of sodium, or common salt; if heated in the gas, it burns very vividly: 24 parts of sodium combine with 36 of chlorine to form 60 parts of this important and well-known compound (*see* Salt.) When chlorine gas is passed into a weak solution of caustic soda it is absorbed, and a useful bleaching and disinfecting solution is obtained, which has been called *Labarracque's disinfecting soda liquid.*

Caustic Soda—Hydrate of Soda.—NaO, HO.—This substance is prepared in practice by decomposing a somewhat dilute solution of carbonate of soda by hydrate of lime; the description of the process employed in the case of hydrate of potash, and the precautions necessary, apply word for word to that of soda.

The solid hydrate is a white, fusible substance, very similar in properties to hydrate of potash. It is deliquescent, but dries up again after a time in consequence of the absorption of carbonic acid. The solution is highly alkaline, and a powerful solvent for animal matter; it is used in large quantity for making soap.

The strength of a solution of caustic soda may be roughly determined from a knowledge of its density, by the aid of the following table, drawn up by Dr. Dalton.

Table of Density.

Density.	Per centage of real soda.
2·00	77·8
1·85	63·6
1·72	53·8
1·63	46·6
1·55	41·2
1·50	26·8
1·47	34·0
1·44	31·0
1·40	22·0
1·36	23·0
1·32	23·0
1·29	19·0
1·23	16·0
1·18	13·0
1·12	9·0
1·06	4·7

Carbonate of Soda.—NaO, CO_2+10HO. Carbonate of soda was once exclusively obtained from the ashes of seaweeds, and of plants, such as the *salsola soda*, which grew by the sea-side, or being cultivated in suitable localities for the purpose, were afterwards subjected to incineration. The *barilla* yet employed in soap-making, is thus produced in several places on the coast of Spain, as Alicant, Carthagena, &c. That made in Brittany is called *varec.*

Carbonate of soda is now manufactured on a stupendous scale from common salt, or rather from sulphate of soda, by a process of which the following is an outline—

A charge of 600 lbs. of common salt is placed upon the hearth of a well-heated reverberatory furnace, and an equal weight of sulphuric acid of sp. gr. 1·6 poured upon it through an opening in the roof, and thoroughly mingled with the salt; hydrochloric acid gas is disengaged, which is usually allowed to escape by the chimney, and the salt is converted into sulphate of soda. This part of the process takes for completion about four hours, and requires much care and skill.

The sulphate is next reduced to powder, and mixed with an equal weight of chalk or limestone, and half as much small coal, both ground or crushed. The mixture is thrown into a reverberatory furnace, and heated to fusion, with constant stirring; 2 cwt. is about the quantity operated on at once. When the decomposition is judged complete, the melted matter is raked from the furnace into an iron trough, where it is allowed to cool. When cold, it is broken up into little pieces and lixiviated with cold or tepid water.* The solution is evaporated to dryness, and the salt calcined with a little saw-dust in a suitable furnace. The product is the soda-ash of commerce, which, when of good quality, contains from 48 to 52 per cent. of pure soda, partly in the state of carbonate, and partly as hydrate, the remainder being chiefly sulphate of soda and common salt, with occasional traces of sulphite or hyposulphite, and also cyanide of sodium. By dissolving soda-ash in hot water, filtering the solution, and then allowing it to cool slowly, the carbonate is deposited in large transparent crystals.

The re-action which takes place in the calcination of the sulphate with chalk and coal-dust, seems to consist, first, in the conversion of the sulphate of soda into sulphuret of sodium by the aid of the combustible matter, and secondly, in the double interchange of elements between that substance and the carbonate of lime.

The sulphuret of calcium, thus produced, combines with another proportion of lime to form a peculiar compound, which is insoluble in cold or slightly warm water.

Other processes have been proposed, and even carried into execution, but the above is found most advantageous.

The ordinary crystals of carbonate of soda contain 10 equivalents of water, but by particular management the same salt may be had with seven equivalents, or sometimes with only one—these differ in figure from the preceding. The common form of the crystal is derived from an oblique rhombic prism: they effloresce in dry air, and crumble to white powder. Heated, they fuse in their water of crystallization: when the latter has been expelled, and the dry salt exposed to a full red heat, it melts without undergoing change. The common crystals dissolve in two parts of cold, and in less than their own weight of boiling water; the solution has a strong, disagreeable, alkaline taste, and a powerful alkaline reaction.

Bicarbonate of Soda.—$NaO, CO^{2}+HO, CO^{2}$.—This salt is prepared by passing carbonic acid gas into a cold solution of the neutral carbonate, or by placing the crystals in an atmosphere of the gas, which is rapidly absorbed, while the crystals lose the greater part of their water, and pass into the new compound.

Bicarbonate of soda, prepared by either process, is a crystalline white powder, which cannot be re-dissolved in warm water without partial decomposition. It requires 10 parts of water at 60° for solution; the liquid is feebly alkaline to test-paper, and has a much milder taste than that of the simple carbonate. It does not precipitate a solution of magnesia. By exposure to heat, the salt is converted into neutral carbonate.

A sesquicarbonate of soda containing $2NaO, 3CO_2 + 4HO$ has been described by Mr. Phillips; like the sesquicarbonate of potash, it cannot be formed at pleasure. This salt occurs native on the banks of the soda-lakes of Sakena in Africa, whence it is exported under the name of Trona.

A new process for manufacturing bicarbonate of soda has been patented in this country, which consists in exposing the crude carbonate of soda, moistened in trays laid on shelves, in an air-tight apartment, into which steam and carbonic acid, from the flue of an anthracite stove, are driven in for 7 or 10 days, until the soda will take up no more acid. It is then found that the soda has absorbed one half an equivalent more of carbonic acid, forming a sesquicarbonate. The mass is taken and ground to powder in a mill. This substance is now used in making domestic bread, and hence is called *bread soda*.

SODA ASH. Crude carbonate of soda.

SODA WATER. This common and refreshing beverage is, as usually prepared, a supersaturated solution of carbonic acid gas in water. True *soda water* was formerly prepared (and is still by some manufacturers) for medical use, chiefly as a remedy for heartburn, and certain forms of dyspepsia and calculous complaints; and consisted of one, two, or three drachms of carbonate of soda, dissolved in a pint of water highly impregnated with carbonic acid. This is often a valuable remedy; but would sometimes be attended by mischievous results, especially if indulged in to the extent to which some persons pursue the use of soda water. The mere aqueous solution of carbonic acid, which is made by forcing the gas into water by a condensing pump, and under a pressure of six or eight atmospheres, is an agreeable and, generally speaking, harmless diluent.

In a strong vessel, whiting or powdered marble is placed, and dilute oil of vitriol poured over it: effervescence immediately occurs owing to the escape of carbonic acid. This gas is conveyed by pipes into the vessel containing the water to be impregnated, into which it is driven with so much force, and under so great pressure, that a large proportion of the gas is absorbed and retained in solution by the water. When the pressure is removed, as when the water is drawn from the fountain, the extra quantity of gas held in solution previously, escapes.

Bakewell's apparatus consists of an external casing of a cylindrical form, with spherical ends, made strong enough to resist a pressure of several atmospheres. There is a partition about two-thirds from the top of the vessel. The bottom part is a receptacle for the chalk, or other suitable material, and water from which the carbonic acid gas is to be generated; then there is a vessel containing diluted sulphuric or muriatic acid, which passes out in small quantities, as required, into the vessel. When the chalk and acid receptacles are to be supplied with those ingredients, the apparatus is to be turned on its pivots to a horizontal position. The apparatus is then to be put into vibration on pivots, by which the chalk and water will be effectively agitated by the motion of a pendulum, while a small portion of acid will escape to keep up the generation of the gas as it passes off to the water, which will, at the same time, by the vibration of the apparatus, be thoroughly mixed with the gas as it escapes into the water.

SOLDERING, is the process of uniting the surfaces of metals, by the intervention of a more fusible metal, which being melted upon each surface, serves, partly by chemical attraction, and partly by cohesive force, to bind them together. The metals thus united may be either the same or dissimilar; but the uniting metal must always have an affinity for both. Solders must be, therefore, selected in reference to their appropriate metals. Thus tin-plates are soldered with an alloy consisting of from 1 to 2 parts of tin, with 1 of lead; pewter is soldered with a more fusible alloy, containing a certain proportion of bismuth added to the lead and tin; iron, copper, and brass are soldered with spelter, an alloy of zinc and copper, in nearly equal parts; silver, sometimes with pure tin, but generally with silver-solder, an alloy consisting of 5 parts of silver, 6 of brass, and 2 of zinc; zinc and lead, with an alloy of from 1 to 2 parts of lead with 1 of tin; platinum, with fine gold; gold, with an alloy of silver and gold, or of copper and gold.

For the simple solders, each of the metals may be used, according to the nature of that which is to be soldered. For fine steel, copper, and brass work, gold and silver may be employed. In the large way, however, iron is soldered with copper, and copper and brass with tin. The most usual solders are the compound, which are distinguished into two principal classes, viz.: hard and soft solders. The hard solders are ductile, will bear hammering, and are commonly prepared of the same metal with that which is to be soldered, with the addition of some other, by which a greater degree of fusibility is obtained.

The hard solder for *gold* is prepared from gold and silver, or gold and copper, or gold, silver, and copper.

The hard solder for *silver* is prepared from equal parts of silver and brass, but made easier of fusion by one-sixteenth of zinc.

The hard solder for brass is obtained from *brass*, mixed with a sixth, or an eighth, or even one half of zinc, which may also be used for the hard solder of copper. It is sold in a granulated form, under the name of *spelter solder*.

The soft solders melt easily, but are brittle, and cannot be hammered. Of this kind are the following mixtures:—tin and lead, in equal parts; of still easier fusion is that consisting of bismuth, tin, and lead, in equal parts; one or two parts of bismuth, of tin, and lead, each one part.

In the operation of soldering, the surfaces of the metal intended to be joined must be made very clean, and applied to each other, and it is usual to secure them by a ligature of iron wire. The solder is laid upon the joint, together with sal-ammoniac and borax, or common glass, according to the degrees of heat intended, and these additions defend the metal from oxidation.

Glaziers use resin; and pitch is sometimes employed.

Tin foil, applied between the joints of fine brass work, first moistened with a strong solution of sal-ammoniac, makes an excellent juncture, care being taken to avoid too much heat.

In joining lead plates together, when solder is objectionable, owing to corrosion occurring, after the surfaces have been cleaned, they are united by melting their edges together with the blowpipe, or by pouring a band of melted lead along the two edges placed in apposition. Chloride of zinc in solution is now used as the substance best adapted for cleaning the surfaces of metals to be soldered.

SPECIFIC GRAVITY. (*See* GRAVITY.)

SPECTRUM. In optics, the name given to an elongated image of the sun or other luminous body, formed on a wall or screen by a beam of undecomposed light received through a small hole, and refracted by a prism. For the different colors and fixed lines of the solar spectrum, and for the refrangibility of the different rays, see the Handbook of Science, of this series.

SPECULUM. In optics, the term *speculum* is usually appropriated to reflectors formed of polished metal; while the term *mirror* is used to signify a reflector of glass.

SPECULUM METAL, with which mirrors for reflecting telescopes are made, is an alloy of two parts of copper and one of tin; its whiteness is improved by the addition of a little arsenic.

SPELTER. (*See* ZINC.)

SPONGE, is a cellular fibrous tissue, produced by small animals, almost imperceptible, called Polypi by naturalists, which live in the sea. This tissue is said to be covered in its recent state with a kind of semifluid thin coat of animal jelly, susceptible of a slight contraction or trembling on being touched, which is the only symptom of vitality displayed by the sponge. After death this jelly disappears, and leaves merely the sponge; formed by the combination of a multitude of small capillary tubes, capable of receiving water in their interior, and of becoming thereby distended. Sponges occur attached to stones at the bottom of the sea, and abound particularly upon the shores of the islands in the Grecian Archipelago. Although analogous in their origin to coral, sponges are quite different in their nature; the former being composed almost entirely of carbonate of lime, while the latter are formed of the same elements as animal matters, and afford on distillation a considerable quantity of ammonia.

Dilute sulphuric acid has been recommended for bleaching sponges, after the calcareous impurities have been removed by muriatic acid. Chlorine water answers better.

The sponges of commerce are usually prepared before they come to the market, by being beaten and soaked in dilute muriatic acid with a view to bleach them, and to dissolve any adherent portions of carbonate of lime. Three kinds are found commonly in the market and known as the Turkey; the variety of the same, which is very rare; and the West Indian. On examining the living sponge of commerce with a power of about 500 linear, the fleshy matter will be distinctly observed, having in its interior gemmæ, which are considered to be the young. These are occasionally given off from the mass of living matter. The greater portion of the mass of sponge consists of small cylindrical threads or fibres, various in size. The spiculæ are not found within these, but in the large and flattened fibres, and varying in number from one to three or more, imbedded in their substance. Sometimes one spiculum projects a half or more from the side of the fibre, and is then only covered with the animal matter at the base, or half way up. The fibres of the West Indian species of sponge have been clearly proved to be solid. In the rare variety of Turkey sponge, the fibres are possessed of vessels which anastomose in various directions, differing much in size, and not imbedded in horny fibre, but in a separate sheath. This true vascular tissue performs very important functions in the economy of the animal during life. In some of the tubes of sponge have been observed small globules, the largest of which measured the 1666th of an inch, and the smallest the 50,000th of an inch. They were accidentally perceived to move from right to left.

The rapid strides made in sponging within the Bahamas, since the year 1847, appear almost incredible. Vast quantities of sponge may be seen covering fences, yards, and housetops, where it is left to dry, after having been previously buried (in order to kill the zoophyte which inhabits it) and washed. It is afterwards divested of the fragments of rocks which adhere to it, pressed and packed in bales, averaging 800lbs. weight, each, for the London market, where it is manufactured into cloth hats, &c., and converted to many useful purposes. We are informed that it has recently become the medium for poultices to wounds instead of cloth. From the 1st January to June 30th, of the year 1849, there were exported nearly 1000 bales of sponge, of the value of at least 25 dollars each—$25,000. On the 1st of January, a very small stock of sponge was on hand, while on the 30th June every dealer in this article had a large stock; therefore, as it is a cash article, there must have been paid to the crews employed in this trade at least 40,000 dollars.

The Mediterranean at one time furnished all the sponges used in Europe, and the very finest are yet fished up around the Isles of Greece. Our finest sponges sell at a very high price.

STAINED GLASS. Under the head of GLASS PAINTING this subject has been already noticed. The following details are additional. The blues of vitrified colors are all obtained from the oxide of cobalt. Cobalt ore (sulphuret) being well roasted at a dull red heat, to dissipate all the sulphur and arsenic, is dissolved in somewhat dilute nitric acid, and after the addition of much water to the saturated solution, the oxide is precipitated by carbonate of soda, then washed upon a filter, and dried. The powder is to be mixed with thrice its weight of saltpetre; the mixture is to be deflagrated in a crucible, by applying a red-hot cinder to it, then exposed to the heat of ignition, washed, and dried. Three parts of this oxide are to be mixed with a flux, consisting of white sand, borax, nitre, and a little chalk, subjected to fusion for an hour, and then ground down into an enamel powder for use. Blues of any shade or intensity may be obtained from the above, by mixing it with more or less flux.

The beautiful greenish yellow, of which color so many ornamental glass vessels have been lately imported from Germany, is made in Bohemia by the following process. Ore of uranium, uran-ochre, or uran-glimmer, in fine powder, being roasted, and dissolved in nitric acid; the filtered solution is to be freed from any lead present in it, by the cautious addition of dilute sulphuric acid. The clear green solution is to be evaporated to dryness, and the mass ignited till it becomes yellow. One part of this oxide is to be mixed with 3 or more parts of a flux, consisting of 4 parts of red lead and 1 of ground flints; the whole fused together and then reduced to powder.

Chrome green.—Triturate together in a mortar equal parts of chromate of potash and flowers of sulphur; put the mixture into a crucible and fuse. Pour out the fluid mass; when cool, grind and wash well with water to remove the sulphuret of potash and to leave the beautiful green oxide of chrome. This is to be collected upon a filter, dried, rubbed down along with thrice its weight of a flux, consisting of 4 parts of red lead and 1 part of ground flints fused into a transparent glass; the whole is now to be melted and afterwards reduced to a fine powder.

Violet.—One part of calcined black oxide of manganese, one of zaffre, ten parts of white glass pounded, and one of red lead, mixed, fused, and ground. Or gold purple (Cassius's purple precipitate) with chloride of silver previously fused, with ten times its weight of a flux, consisting of ground quartz, borax, and red lead, all melted together; or, solution of tin being dropped into a large quantity of water, solution of nitrate of silver may be first added, and then solution of gold in *aqua regia*, in proper proportions. The precipitate to be mixed with flux and fused.

STARCH is a white pulverulent substance, composed of microscopic spheroids, which are bags containing the amylaceous matter. It exists in a great many different plants, and varies merely in the form and size of its microscopic particles; as found in some plants, it consists of spherical particles $\frac{1}{1000}$ of an inch in diameter; and in others of ovoid particles of $\frac{1}{300}$ or $\frac{1}{400}$ of an inch. It occurs—1, in the seeds of all the acotyledinous plants, among which are the several species of corns, and those of other *gramineæ*; 2, in the round perennial tap roots, which shoot up an annual stem; in the tuberose roots, such as potatoes, the *Convolvulus batatas* and *edulis*, the *Helianthus tuberosus*, the *Jatropha manihot*, &c., which contain a great quantity of it; 3, in the stems of several monocotyledinous plants, especially of the palm tribe, whence sago comes; but it is very rarely found in the stems and branches of the dicotyledinous plants; 4, it occurs in many species of lichen. Three kinds of starch have been distinguished by chemists; that of wheat, that called *inuline*, and lichen starch. These three agree in being insoluble in cold water, alcohol, ether, and oils, and in being converted into sugar by either dilute sulphuric acid or diastase. The main difference between them consists in their habitudes with water and iodine. The first forms with hot water a mucilaginous solution, which constitutes, when cold, the paste of the laundress, and is tinged blue by iodine; the second forms a granular precipitate, when its solution in boiling-hot water is suffered to cool, which is tinged yellow by iodine; the third affords, by cooling the concentrated solution, a gelatinous mass, with a clear liquor floating over it, that contains little starch. Its jelly becomes brown-gray with iodine.

1. *Ordinary starch.*—This may be extracted from the following grains:—wheat, rye, barley, oats, buckwheat, rice,

maize, millet, spelt; from the siliquose seeds, as peas, beans, lentiles, &c.; from tuberous and tap roots, as those of the potato, the orchis, manioc, arrowroot, batata, &c. Different kinds of corn yield very variable quantities of starch. Wheat differs in this respect, according to the varieties of the plant, as well as the soil, manure, season, and climate.

Wheat partly damaged by long keeping in granaries, may be employed for the manufacture of starch, as this constituent suffers less injury than the gluten; and it may be used either in the ground or unground state.

1. *With unground wheat.*—The wheat being sifted clean, is to be put into cisterns, covered with soft water, and left to steep till it becomes swollen and so soft as to be easily crushed between the fingers. It is now to be taken out, and immersed in clear water of a temperature equal to that of malting-barley, whence it is to be transferred into bags, which are placed in a wooden chest containing some water, and exposed to strong pressure. The water rendered milky by the starch being drawn off by a tap, fresh water is poured in, and the pressure is repeated. Instead of putting the swollen grain into bags, some prefer to grind it under vertical edge-stones, or between a pair of horizontal rollers, and then to lay it in a cistern, and separate the starchy liquor by elutriation with successive quantities of water well stirred up with it. The residuary matter in the sacks or cisterns contains much vegetable albumen and gluten, along with the husks; when exposed to fermentation, it affords a small quantity of starch of rather inferior quality.

The above milky liquor, obtained by expression or elutriation, is run into large cisterns, where it deposits its starch in layers successively less and less dense; the uppermost containing a considerable proportion of gluten. The supernatant liquor being drawn off, and fresh water poured on it, the whole must be well stirred up, allowed again to settle, and the surface-liquor again withdrawn. This washing should be repeated as long as the water takes any perceptible color. As the first turbid liquor contains a mixture of gluten, sugar, gum, albumen, &c., it ferments readily, and produces a certain portion of vinegar, which helps to dissolve out the rest of the mingled gluten, and thus to bleach the starch. It is, in fact, by the action of this fermented or soured water, and repeated washing, that it is purified. After the last deposition and decantation, there appears on the surface of the starch a thin layer of a slimy mixture of gluten and albumen, which, being scraped off, serves for feeding pigs or oxen; underneath will be found a starch of good quality. The layers of different sorts are then taken up with a wooden shovel, transferred into separate cisterns, where they are agitated with water, and passed through fine sieves. After this pap is once more well settled, the clear water is drawn off, the starchy mass is taken out, and laid on linen cloths in wicker baskets, to drain and become partially dry. When sufficiently firm, it is cut into pieces, which are spread upon other cloths, and thoroughly desiccated in a proper drying-room, which in winter is heated by stoves. The upper surface of the starch is generally scraped, to remove any dusty matter, and the resulting powder is sold in that state. Wheat yields, upon an average, only from 35 to 40 per cent. of good starch. It should afford more by skilful management.

In 1839, M. Pierre Isidore Verduer obtained a patent for making starch, the chief object of which was to obtain the gluten of the wheat in a pure state, as a suitable ingredient in making bread, biscuits, &c. He works wheat flour into dough by a machine, kneads it, washes out the starch by streams of cold water, a process long known to the chemist, and purifies the starch by fermentation of the superjacent water.

Mr. Jones's patent, of 1840, is based upon the purification of the starch of rice and other farinaceous matters, by means of caustic alkali. He macerates 100 lbs. of ground rice in 100 gallons of a solution composed of 200 grains of caustic soda or potash to a gallon of water, stirs it gradually, till the whole be well mixed; after 24 hours, draws off the superjacent liquid solution of gluten in alkali, treats the starchy deposit with a fresh quantity of weak caustic ley, and thus repeatedly, till the starch becomes white and pure. The rice before being ground is steeped for some time in a like caustic ley, drained, dried, and sent to the mill.

Starch is made from wheat flour in a like way. The gluten may be recovered for use, by saturating the alkaline solution with sulphuric acid, washing and drying the precipitate.

In 1841, Mr. W. T. Berger obtained a patent for manufacturing starch by the agency of an alkaline salt upon rice. He prefers the carbonates of potash and soda.

Mr. James Colman, by his patent invention of December, 1841, makes starch from ground maize or Indian corn, by the agency either of the ordinary process of steeping and fermenting, or of caustic or carbonated alkaline leys. He also proposes to employ dilute muriatic acid to purify the starchy matter from gluten, &c.

Mr. Colman has taken out a patent recently for an improved process: the subjoined is the plan given in his specification. Take one ton of rice, either whole or broken, with or without the husk, and submit it to the action of caustic alkaline ley, in the manner at present performed, using soda in preference to potash, as affording a less deliquescent product. Wash the rice so prepared, and then pass it through the grinding or levigating mills in the usual manner, so as to reduce the starchy matter to a pulp, in a fine state of division. The washed pulp so obtained is next to be placed in a churn, together with 40 gallons of a solution prepared in the following manner:—Take 20 lbs. of borax, and dissolve it in such a quantity of hot or cold water as will suffice to form a cold saturated solution; for which purpose about 20 parts of water are requisite for 1 part of borax; pour 40 gallons of clear solution of borax thus made on a bushel of unslacked lime, placed in any suitable vessel; stir the mixture, and add to it enough water to make up the quantity used to 50 gallons. Allow the undissolved portions in the mixture to precipitate, draw off the clear supernatant solution, and place it in the churn with the starch pulp, prepared in the manner before mentioned. The contents of the churn are next to be subjected to agitation for two or three hours, so as to bring each particle of the starchy matter in communication with the alkaline solution. When the desired effect has been produced, the mixture is to be run from the churn into the separating vessel, and about as much water as the churn will hold added to it (dimensions or capacity of churn not given); the whole is to be now well stirred, and the starch washed, boxed, and dried in the usual way. Instead of borax and lime, as above mentioned, the same quantity of solution of borax alone may be used, or a solution of bitartrate of potash and lime, or a solution of bitartrate of potash alone may be employed. In either case, the process is to be conducted as above described. In the case of any other farinaceous or leguminous substance than rice being employed, the material used must be reduced to a fine pulpy state, as in the case of rice, proceeding as above directed.

For the manufacture of starch from the potato, see POTATO STARCH. Indian corn yields, by analysis, over 70 per cent. of starch. The manufacture of starch from corn is an extensive operation in some districts of this country.

There are several other varieties of starch, which are called differently according to the sources whence derived, as sago from tapioca, tous le mois, arrow-root, farina, &c.

The characters of the different varieties of starch can be learned only from microscopic observation; by which means also their sophistication or admixture may be readily ascertained.

Starch, from whatever source obtained, is a white soft powder, which feels crispy, like flowers of sulphur, when pressed between the fingers; it is destitute of taste and smell, unchangeable in the atmosphere, and has a specific gravity of 1·53. We have already described the particles as spheroids enclosed in a membrane. The potato contains some of the largest, and the millet the smallest. Potato starch consists of truncated ovoids, varying in size from 1-300th to 1-3000th of an inch; arrow-root, of ovoids varying in size from 1-800th to 1-2000th of an inch; flour starch, of insulated globules about 1-1000th of an inch; cassava, of similar globules assembled in groups. These measurements have been made with a good achromatic microscope, and a divided glass-slip micrometer of Tully.

For the saccharine changes which starch undergoes by the action of *diastase*, see FERMENTATION.

Lichenine, a species of starch obtained from Iceland moss (*Cetraria islandica*), as well as *inuline*, from elecampane (*Inula Helenium*), are rather objects of chemical curiosity, than of manufacture.

There is a kind of starch made in order to be converted into gum for the calico-printer. This conversion having been first made upon a great scale in England, has occasioned the product to be called British gum.

A delicate and ready test of the presence of starch exists in iodine, with which the starch forms a deep blue color, or, if in the liquid form, a solution colored blue. This color disappears on boiling, re-appears on cooling, and is destroyed by chlorine and sulphuretted hydrogen. To produce the color, the starch should be boiled, and the iodine should be free—that is, not united to any other substance.

STAUROLITE. The mineral called *cross-stone*, *harmotome*, and *Andreasbergolite*. It is a silicate or baryta and alumina, with traces of lime and potash, and forms small quadrangular prisms crossing each other: the most characteristic specimens are from Andreasberg, in the Hartz.

STAUROTIDE. A name given by Haüy, and other mineralogists, to the prismatic garnet, or *grenatite*. It occurs in four and six-sided prisms, sometimes crossing each other at right angles. It is a silicate of alumina and lime, with the oxides of iron and manganese. It occurs in primary rocks, and is distinguished from garnet by its form and difficult fusibility.

STEAM. 1. The vapour of water; or the elastic aeriform fluid generated by heating water to the boiling point. When water in an open vessel is heated to the temperature of 212°, or to the boiling point, globules of steam are formed at the bottom, and rise to the surface; and the continued application of heat, even though increased indefinitely, will only cause a more copious and rapid formation of steam, and will finally evaporate the whole of the water, without raising the temperature of either. In this case, all the heat which enters into the water is solely employed in converting it into steam of the temperature of boiling water. But if the water be confined in a strong close vessel, both it and the steam which it produces may be brought to any temperature; and as steam at 212° occupies nearly 1700 times the space of the water from which it is generated, it follows that, when thus confined, it must exercise an enormous elastic or expansive force; which may also be shown to be proportional to its temperature. When the temperature is considerably above 212°, the steam formed under such circumstances is termed *high pressure steam*; at 212° it is termed *low pressure steam*, and its pressure is equal to that of the atmosphere, or 15 lbs. on the square inch. Steam in its perfect state is transparent, and constantly invisible; but when it has been deprived of part of its heat by coming into contact with cold air, it suddenly assumes a cloudy appearance, and is condensed into water. Hence appears another important property of steam, its condensibility; so that whenever cold is applied to it, it suddenly returns to the liquid state, and thus can be employed to produce a vacuum. From the properties above briefly adverted to, steam constitutes an invaluable agent for the production of mechanical force, as exemplified in the vast and multiplied uses of the steam-engine. Steam is also employed as an agent in distributing the heat used for warming buildings, in heating baths, evaporating solutions, distilling, brewing, drying, dyeing, and even for domestic cookery. It is also the means of extracting wholesome and nutritious food from most unpromising and unpalatable substances. 2. In *popular usage*, the visible moist vapour which rises from water, and from all moist and liquid bodies, when subjected to the action of heat; as the *steam* of boiling water, of malt, of a tan-bed, &c. This is properly water in a minute state of subdivision arising from the condensation of steam.

History of Steam. The nature and properties of steam were altogether unknown to the ancients. Some accounts have come down to us bearing a very early date of engines; such, for example, as that proposed by Hero of Alexandria, in which the mechanical agency of steam was more or less used without any correct notion of its mode of action. Even at a much more recent period the effects produced by steam were ascribed, not to the vapor of water, but to the force of air which was supposed to be expelled from water by heat. In the beginning of the 17th century, De Caus proposed the construction of a machine by which a column of water was raised by the elastic force of steam. About the middle of the same century, Lord Worcester published the description of a high pressure steam-engine, which has since formed so remarkable a feature in all histories of that machine. Towards the latter end of that century, however, the actual properties of vapor began to be gradually unfolded. In 1683, Sir Samuel Moreland published a description of the force of steam, in which he assigned very nearly the exact numerical proportion in which water increases its volume when evaporated under the pressure of a single atmosphere. A few years after, Papin discovered the method of producing a vacuum by the condensation of steam, and the circumstances attending its condensation, became gradually better understood, having been applied to mechanical purposes by Savery, Newcomen, and others. About the middle of the 18th century, the celebrated Watt applied himself to the improvement of the steam-engine, and by various experiments determined the relative volumes of steam as commonly used in steam-engines, and the quantity of heat absorbed in evaporation and evolved in condensation. About the same period Dr. Black was engaged in his well-known investigations respecting the phenomena of heat, and had discovered the phenomena and found the theory of latent heat, which served to explain the effects which Watt had also observed. The relation between the temperatures and pressures of the vapor of water was determined by Dalton, and confirmed by Gay-Lussac, Prof. Robison, Ure, Southern, and others. The discovery of the law in virtue of which the pressure of all gases and vapors increases in proportion to their density at a given temperature was due to Mariotte, and is known as Mariotte's law. The discovery of the remarkable fact that all gases and vapors receive the same increase of pressure or volume for each degree of temperature, was first discovered by Dalton; but was immediately afterwards discovered also by Gay-Lussac, who was not informed of Dalton's proceedings. The most important course of experiments which has since been made were undertaken by a committee of the French Institute, consisting of MM. Prony, Arago, Gerard, and Dulong, in consequence of an application from the French government to the academy to point out the best means of preventing accidents from the bursting of the boilers of steam-engines. The experiments were conducted chiefly by Arago and Dulong, and were certainly not only the most delicate as to their management, but the most hazardous which science and art owe to the courage and zeal of philosophers. Steam was produced of a sufficient pressure to force a column of mercury up a glass tube to the height of nearly 43 feet; an atmosphere being measured by a column of mercury measuring 29·922 inches. Steam has been made use of lately in many novel modes as an effective agent in the arts, a remarkable employment of steam is in distilling substances at a low temperature, which require a high temperature without its use. Turpentine, vinegar, and charcoal may be mentioned. The following table exhibits the temperatures and corresponding pressures of steam as determined by these experiments, up to fifty atmospheres.

Pressure in Atmospheres.	Temperature.	Pressure in Atmospheres.	Temperature.
1	212°	13	380·66°
1½	234	14	386·94
2	250·5	15	392·86
2½	263·8	16	398·48
3	275·2	17	403·83
3½	285	18	408·92
4	293·7	19	413·78
4½	300·3	20	418·46
5	307·5	21	422·96
5½	314·24	22	427·28
6	320·36	23	431·42
6½	326·26	24	435·56
7	331·7	25	439·34
7½	336·86	30	457·16
8	341·78	35	472·73
9	350·78	40	486·59
10	358·88	45	499·14
11	366·85	50	510·6
12	374		

STEAM-CARRIAGE. A name usually applied to locomotive engines adapted to work on common roads.

The principle of the construction of these is in the general conditions, similar to that of the locomotive engine used on railways (*see* LOCOMOTIVE ENGINE); but the engine adapted to common roads must have the same power, with a much less weight; or in other words, the ratio of the weight of the engine to the evaporating power of the boiler is much less than in the case of railway locomotives.

The first carriage was that of Messrs. Trethevick and Vivian, in 1802, 20 years after Mr. Griffith's improvement. Mr. Gordon, followed with various others, down to that of Sir J. Anderson, which appeared only a few years back.

The engine in steam-carriages generally acts either directly on the wheels, and causes them to revolve, and thereby propels the carriage; or it acts on cranks formed on the axle of the wheels, and the wheels being keyed upon the axle are compelled to revolve with it. In either case, the revolution, whether of the wheels or the axle, is produced by a connecting rod jointed on the end of the piston rod, and receiving motion from the piston rod. The wheels are generally driven by two pistons working in two cylinders, so that one is at its dead point when the other is in the position most favorable for its action. The arrangement of this part of the machinery being similar to that of the railway locomotive, need not be here more fully described.

The steam-carriages of different projectors differ one from another, chiefly in the boilers, and in the apparatus for generating the steam and admitting it to the cylinder. Mr. Gurney's boiler consisted of a series of strong iron tubes placed side by side, so as to form the bars of the grate of the furnace. These were connected with another system nearly at right angles to them, forming the back of the furnace, and these again with a third system, forming the roof of the furnace. The tubes forming the grate bars had their ends inserted in a strong iron cylinder, having its axis horizontal, and its length extended across the front of the furnace under the fire-door; and the tubes forming the roof of the furnace were inserted in a similar cylindrical vessel, extending in like manner across the front of the furnace *above* the fire-door. These two cylinders were likewise connected by upright cylinders of less diameter placed at each side of the fire-door. These systems of tubes and cylinders being filled with water, the heat of the furnace acting on the tubes surrounding the fireplace, and the heated air and flame being afterwards conducted above the tubes forming the roof of the fireplace, before it escaped into the chimney, steam was produced in the tubes, which by its lightness passed from them to the cylindrical vessel extending over the fire-door. From that vessel the steam passed into a larger cylindrical vessel above it, called a *separator*, its purpose being to disengage the pure steam from the spray of water with which it is generally mixed when it first escapes from the boiling water in a state of violent agitation.

Every part of this boiler being cylindrical, has the form which is most favorable to strength, and which, within given dimensions, contains the greatest quantity of water. The tubes surrounding the furnace can freely expand in the direction of their length, without being loosened at the joints, and without straining any part of the apparatus. Proper means of opening the tubes at their ends are provided, by which they may be scraped on the inside, and cleansed from any deposit which may be left in them by the water evaporated in them.

The boiler must have the power of generating steam rapidly, strength to secure it from explosion, lightness and compactness. A strong draft on the fire is produced either by an air chamber, or air fans. The operation of steering is usually performed by a hand-wheel at the forepart, giving motion by means of a rack and pinion, or chain and pulley to the fore axle. The brake by which the motion of the steam-engine is arrested usually consists of metal bands capable of being pressed either against the nave or the periphery of the one or both the after wheels.

On railways, a steam engine will readily draw 200 tons 12 miles in an hour, which, compared with a horse at 12 cwt., 8 miles, with 12 traction, is 4000 × 12 = 48,000 to 1152, or nearly 42 to 1. Hence, the engine operates with the power of 42 horses, and if of greater estimated power, the difference is lost in imperfect contact of wheels, in friction, &c. If the horses' speed were taken at 9 or 10 miles, it would accord with cruel practices which ought not to be data, that this would reduce the engine's power only to 35 or 36 horses.

But an engine can work 24 hours per day, and a horse but 1½ hour at this rate; hence, the working power of the engine would be 16 × 42, or 672 horses.

The cost is another consideration; a railway of 12 miles in Britain costs 30 or 40,000*l*. but it will last 20 years; 672 horses and harness would cost 20,000*l*. renewable every four years. The coke for 200 tons for 24 hours, would be 6½ tons,* and assistance about 5*l*, but the horses would cost 75*l*. for keep.

On a *level* railroad, the force of draught, or traction, is about the 240th, *i. e.* 1 cwt. of force is requisite to draw 12 tons. In an ascending road, this force must be increased by the ratio of the rise to the length. Thus, a rise 1 foot in 60 would demand a 60th of the weight, or 12 tons would demand 4 cwt. of force more, or 5 cwt. One foot in 100 would require 2·4 more, or 3·4 cwt. to draw it, and so on. This difficulty is obviated by a horse-wheel at the top of each plane, or by dividing the load at bottom, and re-uniting at top. A station engine, or an extra engine, requires to be made ready. But, in general, an engine does not travel with all its power, so that inclinations of 1 in 240 feet may be surmounted by enlarging the throttle valves, so as to double its own power. A heavy mass, rolling the contrary way, would obviously give the requisite force; while the pulling it up again would be convenient in descents. Lardner suggests lifting stages, on the principle of canal locks.

Perkins showed, that, by increasing the strength of the apparatus, we might use steam, so excited by increased motion as to press with a force of 2000 lbs. to the square inch.

The fire-tubes are now increased from 100 to 150 of 1, 1·5, and 2 inches diameter, so that no heat is lost, and the water is everywhere in contact with the pipes filled with excited air, which, in all cases, is the means of transmitting the motion of fixed oxygen to bodies within its asceuding current.

For security, also, the steam is confined within plates, so that their reduced strength is a constant safety-valve.

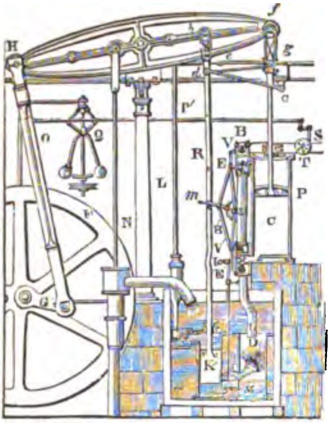
The crank, connected with the wheels, makes a revolution at each stroke of the piston; hence, the velocity is governed by the rapid generation of steam, and this is as the heat. If the wheels are 5 feet or 16 round, 16 into the strokes per minute expresses the velocity on level ground.

STEAM ENGINE. The first actual working steam engine of which there is any record, was invented and constructed by Captain Savery, an Englishman; to whom a patent was granted for it, in 1698. These engines were employed to raise water by the expansion and condensation of steam, and were only pumps. The steam engine received great improvements from the hands of Newcomen, Beighton, Blakey, and others, from 1705 to 1710. Still, however, it was imperfect and rude in its construction, and was chiefly applied to the draining of mines, or the raising of water. The steam engine was brought to its present high state of perfection, by the celebrated James Watt, about the year 1782. The numerous and vital improvements introduced by him, both in the combination of its mechanism, and in the economy of its management, have rendered the steam engine at once the most powerful, the most easily applied and regulated, and, generally speaking, the least expensive of all prime movers, for impelling machinery of every description. Steam engines vary much in magnitude, form, and proportions, as well as in the details of the machinery by which the power of the steam is applied. In short, the form of the engine, the arrangement and construction of its parts, its power, &c., depend entirely on the purpose to which it is to be applied, and may be indefinitely diversified. The form of the steam engine is susceptible of an endless variety, according to the purposes to which it is to be applied; its mechanical energy is usually estimated in *horse power*, (*see* HORSE POWER,) and is proportioned to the pressure of the steam, the area of the piston, and the velocity at which it moves. The stupendous effects which have resulted from the application of the power of steam in recent times, are striking attestations of the immense value of the invention. By the agency of steam, the seas are now navigated in defiance of wind and tide; the earth is made to yield up in lavish abundance its metals and minerals; vast marshes are drained, and land before barren rendered fruitful; communities are brought into closer connection with communities; fresh and inexhaustible sources of wealth and comfort are elicited; new combinations of human industry and ingenuity are brought into requisition; knowledge is widely scattered abroad; distance is lessened by velocity of locomotion; and time itself becomes more precious. Thus by infinitely enlarging the sphere of useful action to whatsoever was useful before, and by diffusing among millions what previously was attainable only by the few, this agent has wrought a change of aspect in kingdoms, in commerce, and in the individual relations of society, to an extent so wide, and in a time so brief, that the history of the world bears no parallel to it in influence.

The following is a description of the various forms of engines commonly in use:

Double-acting Condensing Steam-Engine. This form of engine is that which is almost invariably used as a moving power in almost all manufactures. It consists of a cylinder represented in section at C, in which a moveable piston P is driven upwards and downwards by the force of steam supplied by a boiler placed near the engine.

This piston gives motion to a *working beam* H *f*, which, by means of a heavy bar O, called a *connecting rod*, moves a *fly-wheel* and *crank*, from which the machinery to be worked directly receives its motion. Steam is supplied from the boiler to the cylinder by the steam-pipe S. The *throttle-valve* T in that pipe, near the cylinder, is regulated by a system of levers connected with the *governor* Q. This governor is an apparatus consisting of two heavy balls attached to the ends of rods which are kept revolving on a vertical shaft by a cord or band, or by a train of cogged wheels connected with the fly-wheel. The velocity with which the balls of the governor revolve is therefore always proportional to that of the fly-wheel, and of the machinery driven by it. If, by reason of too rapid a supply of steam, an undue speed be imparted to the fly-wheel, the balls



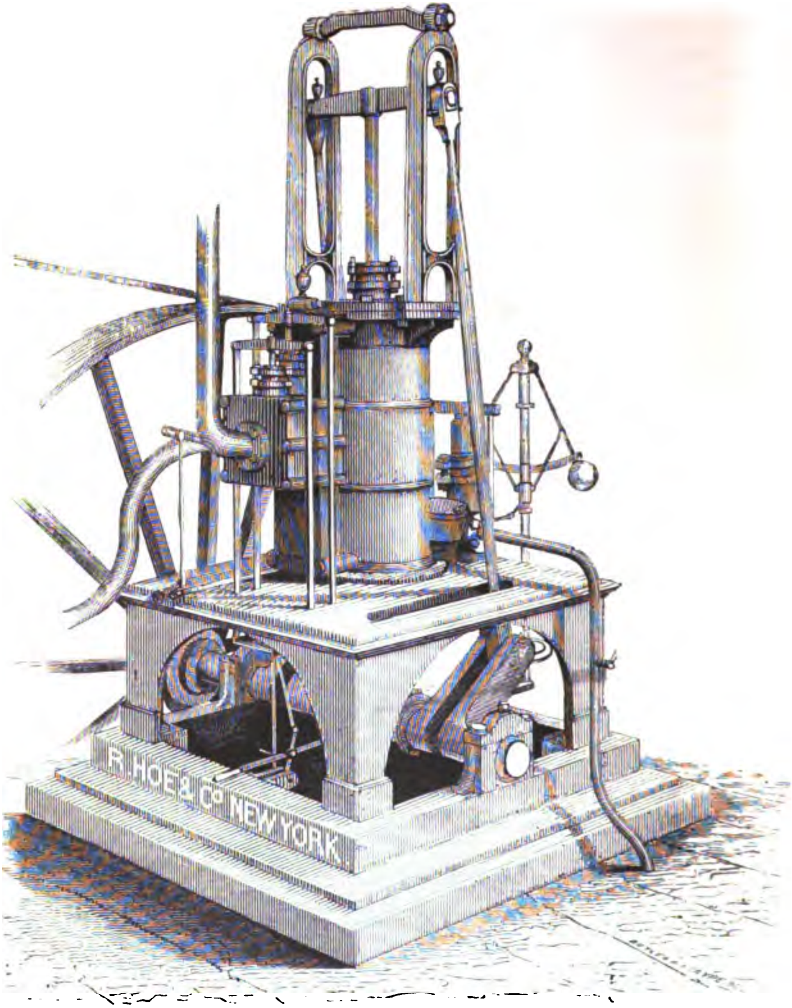
are whirled round with a corresponding velocity; and by reason of their centrifugal force they recede from the vertical spindle round which they turn, and acting thereby on the system of levers which connect them with the throttle-valve T, they partially close the latter, check or diminish the supply of steam to the cylinder, and moderate the velocity of the machine. If, on the other hand, the motion of the engine be slower than is requisite, owing to a deficient supply of steam through S, then the balls, not being sufficiently affected by centrifugal force, fall towards the vertical spindle, and acting on the system of levers in the contrary way, they turn the throttle-valve T more fully open, and admit a more ample supply of steam to the cylinder, so as to increase the speed of the engine to a requisite limit.

The piston P is accurately fitted to the cylinder, and made to move in it steam-tight by packing, with which it is surrounded. This piston divides the cylinder into two compartments, between which there is no communication by which steam or any other elastic fluid can pass. A case B B' placed beside the cylinder, contains the valves by means of which the steam which impels the piston is admitted and withdrawn, and the piston commences its motion in each direction. The *upper steam-box* B is divided into three compartments by two valves: above the upper steam-valve V is a compartment communicating with the steam-pipe S. Below the exhausting valve E is another compartment communicating with a pipe called the *eduction-pipe*, which leads downwards from the cylinder to a vessel called the condenser, which we shall presently describe. By this eduction pipe the steam is withdrawn from the cylinder after it has driven the piston. By the valve V a communication may be opened or closed between the boiler and the top of the cylinder, so as to admit or intercept the supply of steam from the one to the other. By the valve E a communication may be opened or closed between the top of the cylinder and the condenser, so that the steam in the top of the cylinder may either be permitted to escape into the condenser or confined in the cylinder. The continuation S' of the steam-pipe leads to the *lower steam-box* B, which, like the upper, is divided into three compartments by two valves V' and E'. The upper compartment communicates with the steam-pipe S', and the lower with the eduction-pipe. By means of the valve V' steam may be admitted from the steam-pipe S' to the bottom of the cylinder, and by means of the valve E' this steam may be permitted to escape to the condenser.

The four valves V, E, V', and E', are in the engine represented in the figure connected by a system of levers with a single handle or *spanner m*, which being pressed upwards or downwards opens and closes the valves in pairs. Thus when it is pressed *down*, the levers connected with it raise the upper exhausting valve E and the lower steam valve V', and close the upper steam valve V and the lower exhausting valve E'. On the other hand, when the spanner *m* is pressed *up* it opens the upper steam valve V and the lower exhausting valve E', and at the same time closes the upper exhausting valve E and the lower steam valve V'.

Mr. Piment has improved the mode of condensing the steam after it has done its duty in the cylinder. The steam on leaving passes into tubes surrounded by water intended for the boiler, which condenses it quickly, and is itself warmed. One great advantage is the great purity of the water so obtained thereby preventing incrustation, and the water itself being heated up to 95°, there is a saving of fuel. It is now extensively used.

Perkins's High-Pressure and Safety-Engine is made applicable to all purposes of steam navigation, and consists of a steam-pipe from the generators, conveying the steam to the admission-valve, lying horizontally at the back of the


R. HOE & Co NEW YORK

VERTICAL STEAM ENGINE—For Manufacturing Purposes. Page 593.

cylinder, from whence it acts on the underside of the piston at a pressure of 2000 lbs. on the inch. The cylinder is about a 15-horse-power; the piston only six inches in diameter; and the length of stroke only 20 inches.

Palmer's apparatus, as well as Brunton's, consumes the smoke, or supplies sufficient air for the purpose, either by condensation or exhaustion, turning from right to left or left to right.

By placing vane-wheels within the chimney of the boiler of a small steam-engine, the smoke and hot air is returned through the fire and passed downwards, in a current, towards the ground. Sometimes an air-pump has been used instead of a fan, and no chimney is requisite; hence steam-carriages emit no smoke.

Non-condensing Steam-Engines. The form and structure of non-condensing engines differ in nothing from that of double-acting condensing engines, except in the absence of the condensing apparatus; that is to say, the condenser, the air-pump, and the cold water and hot water pumps. The steam, after it has impelled the piston, instead of being conducted to a cold vessel to be condensed, is simply allowed to escape into the atmosphere, and is commonly ejected into the chimney of the furnace.

The operation of such a machine is extremely simple. The valves by which the steam is admitted to, and allowed to escape from the cylinder, are exactly similar to those of the double acting engine. In the down stroke of the piston, the upper steam valve being open, admits steam from the boiler above the piston, and the lower exhausting valve allows the steam below to escape through a tube which leads to the chimney, up which it rushes. In the up stroke, the lower steam valve being open admits steam from the boiler below the piston, and the upper exhausting valve being open allows the steam above the piston to escape to the chimney.

It is evident, in such a machine, that the piston is always resisted by the pressure of the steam escaping to the chimney. As such escape cannot be effected except by steam of greater pressure than that of the atmosphere, it follows that the piston is always resisted by a force somewhat greater than the atmospheric pressure. The steam which urges the piston is, therefore, only effective by the excess of its pressure above that of the escaping vapor, which may be taken at about 16 lbs. per inch, but which varies in different engines.

As the steam used in non-condensing engines must of necessity have a pressure considerably exceeding that of the atmosphere, such machines have been generally called *high-pressure engines;* while those which condense the steam have been, on the other hand, called *low-pressure engines.* These terms are not, however, correctly expressive of the nature of these engines respectively. Since the pumps of the non-condensing engine are dispensed with in this, the beam may be so likewise, and a still further simplification results from an oscillating movement given to the cylinder; such are termed *vibrating* engines, and are successfully used where space is limited as in marine engines. Many engines in which condensation is used, especially those in which the expansive principle is applied with much effect, are worked with steam of a high pressure, not unfrequently with a pressure amounting to from two to three atmospheres. It is, therefore, not correct to call such machines low pressure engines. It is, however, true that engines worked without condensation must, of necessity, be worked by steam of a pressure which is generally called *high pressure.*

An improvement in oscillating engines has been introduced, which consists in the substitution of a circular valve for the ordinary slide valve, thus dispensing with eccentric guides, which renders the engine less complicated, more easily managed, as one lever suffices for use. It is especially applicable to small river boats.

All locomotive engines, without exception, used on railways or common roads, are high-pressure non-condensing engines. (*See* LOCOMOTIVE ENGINE, and STEAM CARRIAGE.)

High-pressure non-condensing engines are almost universally used for inland navigation at the West and South.

The accompanying engraving represents a vertical high-pressure engine, not occupying much space, and adapted for printing or manufacturing purposes.

Rotary Steam Engine.—This term is sometimes applied to the double-acting engine working a crank and fly-wheel, as distinguishing it from the single-acting engine used for pumping. But it is more properly applied to an engine in which a motion of rotation is produced immediately by the action of steam, without the intervention of such mechanism as the working beam, crank, and fly-wheel. This is usually effected by a piston, which, instead of moving longitudinally in the cylinder, revolves within the cylinder on an axis which coincides with the geometrical axis of the cylinder itself. The mechanism is so contrived that this piston shall revolve in steam-tight contact with the sides and ends of the cylinder; and that while steam from the boiler constantly presses it on one side, the steam on the other side shall continually escape to the condenser, if it be a condensing engine, or to the chimney, if it be a non-condensing engine. The various contrivances for rotary engines which have been suggested differ one from the other only in the mechanical expedients by which these ends are attained. Such machines are very numerous and various.

A cubic inch of water becomes very nearly a cubic foot as vapor, or steam of the first degree, exactly 1689, and there are 1728 cubic inches in a foot. When water is at 212, it requires 6 times the heat to vaporize a foot that it did to raise a foot from ice to 212°; and if 1 foot of water, as steam, be mixed with 6 of water at 32, it becomes 7 at 212, showing that there is 6 times the motion in steam that there is in water, yet, as density is inversely as bulk, a thermometer in such steam still stands at 212°.

The *power* of every stroke of an engine is easily estimated. Square the inside diameter of the piston in inches, and multiply by 0·7854. Or, square the inside circumference in inches, and multiply by 0·07958. Then, with an atmospheric power, multiply by 15, and allow for friction and loss of power a fourth or fifth. With a real steam-power or high-pressure engine multiply by the number indicated by heat less the atmospheric pressure, as 50, 200, or 300, as it may be, and allow a fifth friction.

Effect, or work, is as the number and length of strokes per minute, since the power is the multiple of the first force by the velocity.

Eight square feet of the surface of the boiler must be acted on by the fire, to convert a cubic foot of water into steam in an hour, and then it becomes 1728 cubic feet; that is, from 1 foot each way to 12 feet in each dimension. The number of atoms is the same, and they merely fill a larger space by their combined motions.

The power is equal to the expansion or volume. At 212, the steam to the water is as 1728 to 1, which give a force of 15 lbs. to the square inch; but, at 227¼° to the volume is 5 times greater, or 9000 to 1; at 250¼, is 15 times greater, 27,000 to 1; and, at 282°, is 40 times greater, or 72,000 steam to 1 of water, with a power of 55 lbs. to the square inch. Brunton says it may be expanded to 400 times its bulk at 212°. Its force depends on the power and continuity of compression, or reaction, and the vast increase is an accelerated power.

Expansive Engine.—As the operation of the steam engine has been explained, the power which moves the piston is the immediate force with which vapor is produced in the boiler. Each quantity of water which is successively evaporated obtains the space requisite for it in the form of steam, by pressing towards the cylinder an equal quantity of steam previously contained in the boiler; and it is the force with which the steam is thus pressed forward that impels the piston. Great additional mechanical power will be obtained from the steam, if, besides this moving power which results from immediate evaporation, the expansive power of the steam separated from the water be used. This is accomplished by closing the valve through which steam flows from the boiler to the cylinder before the piston has completed its stroke. Thus, let us suppose that when the piston has advanced through half its stroke the steam valve be closed, the steam which is then acting upon the piston will still urge it forward; but as the piston advances, this steam, assuming a proportionally augmented volume, will acquire a gradually diminished pressure, so that through the remaining half of the stroke the piston will be urged by a pressure progressively decreasing, and at the termination of the stroke, it will be a little less than half the force with which the piston was impelled while the steam valve was opened.

Since the force of the steam, from the moment the steam valve is closed, is thus continually diminished, its moving power might be so much attenuated that it would be incapable of overcoming the resistance so as to complete the stroke; this would happen if the steam were cut off when only a small fraction of the stroke has been made, unless the pressure of the steam while the valve is open exceeds the resistance in a proportionate degree. It is for this reason that the expansive principle cannot be brought into operation to any considerable extent, unless steam be used of a greater pressure than is commonly adopted in low-pressure engines. It is also apparent that with an equal volume of cylinder greater length of stroke should be given when the expansive principle is used.

The mechanism by which the expansive principle is brought into practical operation, consists merely in the adaptation of valves or slides, which shall stop the admission of steam when the required fraction of the stroke has been made by the piston, but which shall leave the communication with the condenser open till the stroke is completed. If separate valves be used, this is accomplished by adapting the pins or other mechanism by which they are worked to open and close them, independently of each other, at the proper times. If slides be used, it is effected by regulating the form and aperture of the slide, so as to cover and uncover the passages to the cylinder at the proper times. Each species of valve, and each form of slide or cock, has its own peculiar provisions for accomplishing this.

Single-acting Steam Engine. — When the steam engine is applied to the purpose of pumping water, which in the first periods of its invention was its only practical application, the force which it exerts is only required in raising the pump rods with their load of water, their own weight being more than sufficient for their descent. As the pump rods are attached to the working end of the beam, the force of the steam is only required to draw up that end, and, therefore, to draw down the end at which the steam piston is attached; the steam, therefore, being only required to press the piston downwards, it is not admitted from the boiler above it, as in the engine already described, which for distinction is called the double-acting engine. During the down stroke of the single-acting engine the performance of the machine is precisely similar to that already described; steam is admitted through the upper steam valve above the piston, while the space in the cylinder below the piston is kept in free communication with the condenser by keeping the lower exhausting valve open. The operation, therefore, of the upper steam valve, and the lower exhausting valve, is precisely the same as in the double-acting engine. When the piston has reached the bottom of the cylinder, the two former valves being closed, a valve called the equilibrium valve is opened, by which a free communication is made between the top and the bottom of the cylinder: by this means the steam which fills the upper part of the cylinder, being allowed to flow equally to the lower part, will press with the same force on both sides of the piston, and will, therefore, have no tendency whatever to move it. Under these circumstances, the preponderating weight of the pump rods suspended from the other end of the beam will draw the piston to the top of the cylinder; while it is ascending the steam which was above will pass through the equilibrium valve below it, and when the piston has reached the top of the cylinder, the cylinder under the piston will be filled with the same steam which previously had driven the piston down.

Upon the occurrence of the next down stroke, the equilibrium valve is closed, and the upper steam valve and lower exhausting valve are opened; the steam pressure acts above the piston, and a vacuum is produced below it, and the piston descends as before.

Atmospheric Engine.—The engine so called was the first form of steam engine which was ever brought into extensive and durable practical application, and in districts where fuel is cheap and abundant the simplicity of its structure still keeps it in partial use. Steam, in the atmospheric engine, is only used as an agent for the production of a vacuum, in order to give effect to the atmospheric pressure. It was originally only used for pumping water.

The atmospheric engine, which is only applied to pumping, consists of a cylinder open at the top, having a piston which moves in it air-tight and steam-tight. The piston is thus maintained by being lubricated by oil or melted tallow poured above it. Supposing the piston to be at the bottom of the cylinder, steam is admitted from the boiler by a proper valve. This steam, having a pressure not much exceeding that of the atmosphere, will balance the pressure of the atmosphere above the piston, and will be sufficient, also, to overcome the friction of the piston with the cylinder. Under such circumstances, the preponderating weight of the pump rod at the other end of the beam draws the piston to the top of the cylinder, in the same manner as the piston is drawn up in the single acting steam engine already described. The piston being thus suspended at the top of the cylinder, the valve admitting steam from the boiler is closed, and another valve or cock is opened by which a jet of cold water is thrown into the cylinder. This immediately condenses the steam, and leaves a vacuum under the piston. The atmospheric pressure above it consequently takes effect, and, forcing the piston to the bottom of the cylinder, draws the pump rods, with their load of water, up. When the piston arrives at the bottom of the cylinder, the cock admitting the jet of cold water is closed, and another is opened, by which the warm water formed by the mixture of the condensed steam with the cold water of the jet is discharged into a reservoir from which the boiler of the engine is fed. The steam is then again admitted from the boiler, the piston ascends, and so the process is continued.

The cocks or valves above mentioned are opened and closed at the proper times by means of a rod or beam, called the *plug frame*, attached to the working beam, which is placed and which is moved in a manner similar to the rod of the air-pump in the steam engines already described.

STEAM NAVIGATION. The art of applying the power of steam to the propulsion of boats and vessels in general, as well for inland communication by rivers and lakes, as for the general purposes of national commerce on the seas and oceans by which the various parts of the globe are separated.

To save space, marine boilers are constructed so as to produce, within the smallest possible dimensions, the necessary quantity of steam. With this view, a more extensive surface in proportion to the capacity of the boiler is exposed to the fire. The flues by which the flame and heated air are conducted to the chimney are so constructed that the heat shall act upon the water on every side in thin oblong shells or plates. This is accomplished by constructing them so as to traverse the boiler backwards and forwards several times before they issue into the chimney. The bottom of the boiler is not, therefore, one uniform flat or arched surface, as in land boilers; but is divided by a number of plates placed in a vertical position side by side, having spaces between them alternately appropriated to the water to be heated and the air from the fire. This division is, in some boilers, not only made in the bottom on a level nearly with the furnace, but another stratum of similar flues and water spaces is constructed above the level of the furnace; so that the heated air first traverses the lower stratum of flues, and afterwards, being conducted upwards, traverses the upper stratum before it issues into the chimneys.

In steam vessels, instead of effecting the necessary evaporation by a single boiler, it is usual to provide two, three, four or more, independent boilers, according to the magnitude of the vessel and the power of her engines. By this means, when at sea, the engines may be worked by some of the boilers while others are being cleaned or repaired.

The manner in which the steam engine is rendered an instrument for the propulsion of vessels must, in its general features, be so familiar to every one as to require but short explanation. A shaft is carried across the vessel, being continued on either side beyond the timbers; to the extremities of this shaft on the outside of the vessel, are attached a pair of wheels, constructed like under-shot water wheels, having fixed upon their rims a number of flat boards called *paddle boards*. As the wheels revolve these paddle boards strike the water, driving it in a direction contrary to that in which it is intended the vessel shall be propelled. The moving force imparted to the water thus driven backwards by reaction on the vessel propels it. On the paddle shaft are constructed two cranks or winches, placed at right angles one to the other, so that whenever one of them is thrown into the highest or lowest position, the other is horizontal. These cranks are worked by strong iron rods called *connecting rods*, which are themselves either driven directly by the pistons of two steam engines, or are worked by beams or levers; thus the medium of working becomes similar to those used in the ordinary land engines. (*See* STEAM ENGINE.) The two cranks being placed at right angles, it follows that when one piston is at the top or bottom of its stroke, and the crank driven by it in the highest or lowest position, the other will be at the middle of its stroke, and the crank driven by it will be in the horizontal position. One of the pistons is therefore always in a position to produce the most advantageous effect on the crank at the moment that the other piston loses all power over the crank driven by it; and in the same manner it may be seen that while the power of one piston is augmented from zero to its greatest effect, the power of the other is decreasing from its greatest effect to zero. Thus the combined action of the two pistons is nearly uniform to its efficiency.

If one engine only were used, the motion of the wheels would be unequal, being most rapid when the piston is at the middle of the stroke and slowest at the extremities.

The steam engines used for navigation may be either condensing engines or non-condensing engines. If the latter are used, steam must be used having a pressure above the atmosphere of from 15 to 20 lbs. per square inch. Boilers in which steam is produced under this pressure are considered in Europe so unsafe, that there condensing engines with low pressure boilers are almost universally used for navigation. On this continent, however, high-pressure boilers with non-condensing engines are generally used.

The arrangement of the parts of marine engines is different in several respects from land engines. Steam vessels being generally employed to navigate the open seas, and being, therefore, subject to the vicissitudes of tempestuous weather, the machinery must be protected by being placed below the deck. The space allotted to it being thus limited, great compactness is necessary. The paddle shaft being very little below the deck, the working beam and connecting rod could not be placed above it. Two beams are used —one placed on either side of the cylinder. These have a common centre of oscillation, which is placed near the bed of the engine. At the one end, *links* from the *cross-head* of the piston are connected with the beams; at the other, through the intervention of a *cross-tail*, the connecting-rod is attached, thus completing the connection with the crank.

Where sea water is used in the boilers, as the water evaporates the salts are deposited in an insoluble form on the inner surface of the boiler, forming a *crust* difficult to remove, and causing loss by preventing the heat reaching the water in the boiler until the metal is heated very hot, when explosions are liable to occur.

Dr. Davy, on the best method of preventing the incrustation in the boilers of steam vessels, says, it is principally crystalline in structure, composed chiefly of sulphate of lime. To prevent the deposition of the incrusting matter, the addition of muriate of ammonia and sulphate of ammonia have been employed, but without success. The introduction of a certain quantity of sawdust or tallow, or a mixture of tallow and plumbago, to prevent close adhesion and the more easy separation of the incrusting matter by percussion, using a chisel hammer, or by contraction and unequal expansion by means of flame kindled with oakum after emptying the boiler and drying it, has been attempted, with partial success. The best method is that of "blowing off," that is, discharging by an inferior stop-cock a certain quantity of the concentrated water by the pressure of steam, after the admission above of an equivalent quantity of sea water of ordinary density. A certain preventive would be the substitution of distilled or rain water in the boiler for sea water. But in sea steamers, in which sea water is used, or any water containing sulphate of lime, the prevention of deposition may be effected by keeping the water at that degree of dilution at which the sulphate of lime is not separated from the water in which it is dissolved. Sulphate of lime is hardly less soluble in water saturated with common salt than in perfectly fresh water. The great object in sea steamers is to economize the escape of water in the form of steam, and thereby heat and fuel, also to use fresh water as much as possible, and to avoid using sea water near coasts and parts of seas where sulphate of lime is most abundant.

The method by which the water in the boiler is prevented from being over salted, has been usually to discharge into the sea a certain quantity of over salted water (called *brine*), and to supply its place by sea water introduced through the condenser, and which, being mixed with the condensed steam, is rather less salted than ordinary sea water. To effect this, cocks, called *blow-off cocks*, are placed in the lower part of the boiler where the brine collects. The pressure of the steam is sufficient to force the lower strata of water out through these cocks when they are open, and this process is called *blowing out*. It is, or ought to be, practised at such intervals as will prevent the water from becoming over salted.

The improper observance of this process is attended with injurious effects at sea. If too much water be blown out, a proportionate loss of heat and waste of fuel is incurred. If insufficient water be blown out, incrustation takes place, and its injurious consequences ensue.

Where there is plenty of boiler-room no boiler is like the long cylinder one with return flues. It is the safest and best. For compactness the tubular boiler is best, but then it needs pure water, for it has so many joints that it is difficult to prevent leakage, owing to the expansion and contraction; incrustations are also sure to act injuriously towards the end of a tedious sea voyage. Tubular boilers are peculiarly liable to priming, and great danger arises from this cause. A scale of about 1-16th of an inch is formed in the interior of the boilers of our ocean steamers, during one passage between New-York and Liverpool, and the evil of this is far greater in tubular than it can be in any other boiler. It is very difficult to maintain the feed of tubular boilers at a uniform height, owing to the smaller quantity of water in them than in the common boilers; the only remedy is carefulness on the part of the engineers—when this is wanting, then there is danger.

As the voyages accomplished by steam vessels have increased in length, the economy of fuel in working them has become a subject of vastly augmented importance. So long as steam navigation was confined to river or channel transport, or to coasting voyages, the speed of the vessel was a paramount consideration, at whatever expenditure of fuel it might be obtained; but since steam navigation has been extended to ocean voyages, where coals must be transported sufficient to keep the engine in operation for a long period of time without a fresh relay, greater attention has been bestowed on economizing it. Since the resistance of a steam vessel to the moving power produced by the action of the paddle wheels varies with the state of the weather, the consumption of steam in the cylinders must undergo a corresponding variation; and if the production of steam in the boilers be not proportioned to this, the engines will either work with less efficiency than they might do under the actual circumstances of the weather, or more steam will be produced than the cylinders can consume, and the surplus will be discharged to waste through the safety valves. The fireman of a marine engine must, therefore, in a certain degree, discharge the functions of a self-regulating furnace, rendering the force of the fire always proportionate to the wants of the engine. None but the most industrious and skilful stokers can be expected to accomplish this.

Until within a few years of the present time the heat radiated from every part of the surface of the boiler was allowed to go to waste, and to produce injurious effects on those parts of the vessel to which it was transmitted. This evil has been lately removed by coating the exterior of the boilers with felt prepared for the purpose, by which the escape of heat from the surface of the boiler is very nearly if not altogether prevented. This felt is attached to the plates of the boiler by a thick covering of white and red lead.

The method by which the greatest amount of practical effect can be obtained from a given quantity of fuel must mainly depend on the extensive application of the expansive principle. (*See* STEAM, STEAM ENGINE). The difficulty of the application of this principle in marine engines has arisen from the objections entertained in Europe against the use of steam of high pressure under the circumstances in which an engine must be worked at sea. This objection is not felt in this country, where all the river steamers act on the expansive principle. To apply the expansive principle with great effect, it is necessary that the moving power at the commencement of the stroke shall considerably exceed the resistance, its force being gradually attenuated till the completion of the stroke, when it will finally become less than the resistance. This condition may be fulfilled without resorting to steam of high pressure, if a sufficient quantity of piston surface be used. This method of rendering the expansive principle available for navigation and compatible with low-pressure steam has recently been modified in England by Messrs. Maudsley and Field. Their improvement consists in adapting two steam cylinders in one engine to work a single crank, both pistons ascending and descending together, the piston rods being both attached to the same horizontal cross-head moving in guides.

About the year 1833, Mr. Field proposed the *split paddle*, which is now coming into very extensive use. In this wheel each paddle board is divided into two or more narrow slips arranged one behind the other, like the laths of a Venetian blind or the steps of a step-ladder. These wheels are as efficient in propelling when at the lowest point as the common paddle boards; and when they emerge the water escapes simultaneously from each narrow board, and is not thrown up, as is the case with the common paddles.

The construction of a good and efficient paddle is still a desideratum.

The problem of the application of steam power to water transport presented itself in the United States under conditions very different from those under which it offered itself in Europe, and its solution has accordingly been productive of very different results. While the chief objects of the commercial interests in Europe was the establishment of lines of steam vessels connecting the great cities and coast towns of the British dominions with each other, and with those of the Continent, and as the art advanced, to extend the same social and commercial benefit to the coasts of the chief countries of Europe, so as to stimulate the social intercourse of nations too long disunited and struggling in unprofitable warfare, and thereby to diffuse equally among all the the benefits of general commercial intercourse, America, standing alone in her vast extent of territory, having no near neighbors with whom to cultivate social or commercial relations, regarding her immense country intersected by some of the most noble rivers in the world, enriched by the largest sheets of inland water which can be found upon the globe—thus situated, she saw that *inland navigation*, river and lake transport, was the great application of steam by which her rising and enterprising population would be most benefited, and by which the necessary intercourse could be maintained between her great western emporiums erected on the banks of the Mississippi and Ohio; her more northern settlements on the coasts of the gigantic lakes Ontario, Erie, Michigan, and others; and on the eastern rivers, the Hudson, the Delaware, and the Susquehanna. It was, therefore, to the construction of steamboats suitable to such internal navigation that American genius was directed; and in this it has been eminently successful above every other country in the world.

Our river steamers are, in general, long, narrow boats with a small draught of water, supporting a platform or deck of vast magnitude projecting on either side considerably beyond the limits of the boat on which it rests. The paddle wheels are large, and are impelled by single or double engines placed with their boilers and machinery *above the deck*. The engines are almost universally non-condensing high-pressure engines, and many of them are worked expansively. The fuel is generally wood; but in many cases, especially in the eastern vessels, coal. Owing to the form of the boats, and the smooth water in which they work, a much greater average speed has been obtained than in the sea-going steamers of Europe. On the Hudson, between New-York and Albany, where steam navigation first commenced, are the fastest steamers in the United States; and it is probable that if the average speed of these vessels, taken in all circumstances of weather and tide, be stated at 18 or 20 geographical miles an hour, it is not overrated; and in one instance lately (*the Reindeer*), the passage between the two cities was made at the rate of 24 miles per hour.

The Mississippi is navigated by many hundred steamers of very large tonnage. This steam traffic is carried on through a distance of nearly 2000 miles from the mouth at New Orleans. The towns of Natchez, Cincinnati, Louisville, Pittsburgh, and numerous others, maintain, by this means, an easy and constant intercourse with the capital of the Southern States.

The steamers of the Mississippi vary in magnitude from 100 to above 1000 tons, and, unlike the light mould of the Hudson steamers, they are heavily built, so as to give them abundant tonnage for goods. They are built with a flat bottom, with a draught of from 6 to 8 feet of water. A deck is supported by the hull at about 5 feet above the level of the water, and the space in the hull under this deck is appropriated to the cargo. The whole of the steam machinery is placed on this deck, the engine standing in the middle of the vessel, and the boilers and furnaces towards the bow.

The engines are constructed with very small cylinders, worked with steam of great pressure. The diameter of the cylinder is often under 18 inches, while the length of stroke is from 5 to 6 feet. The safety-valve is usually loaded with 100 lbs. per square inch, which, at the discretion of the captain, is sometimes increased to 150 lbs. Some of the large boats on the Mississippi are equal in magnitude to those on the Hudson, having a length of 260 feet, and a breadth of beam of 30 feet. With this great magnitude of deck and a capacity of not less than 1000 tons, they do not draw above 8 feet of water.

The dimensions of the steamers which ply on the Hudson are generally as follows: The length of deck from 150 to 300 feet; the breadth of beam from 20 to 36 feet; and the depth of the hold from 8 to 10 feet. They are generally, but not always, worked by a double engine; the length of stroke is never less than 8 feet, but the most common length is 10 feet; the diameter of the piston varies from 40 to 66 inches, and the diameter of the paddle-wheels from 20 to 25 feet; the breadth or rather the thickness of the wheel, varies from 12 to 14 feet, giving a great extent of surface to the paddle-boards, draught of water of these boats varies from 4 to 6 feet; the steam is generally worked expansively, being cut off at half the stroke, and often sooner; the wheels are said to make on an average from 25 to 30 revolutions per minute.

The progress which steam navigation has made upon our lakes and western rivers is almost incredible. But a few years past, and all the trade of the Wilderness of the West was carried down the inland waters by lumber boats and vessels of small draught and tonnage.

In 1811, the first steamboat, the *Orleans*, was launched at Pittsburgh, on the Ohio.

In 1818, the *Walk in the Water* appeared upon Lake Erie; and in 1819, she floated over Lake Huron.

In 1826, the first steamer was seen at Lake Michigan; and

In 1832, a steamboat first touched at Chicago.

At the present time the vessels on the Mississippi, the Ohio, and their tributaries, are over 600, with a tonnage of 140,000 tons, a larger amount than is at present engaged in the coast trade of England. In 1849, the United States Senate printed a document, which estimates the commerce of the Western rivers at $256,233,840 for that year. The commerce of the lakes is now equal to nearly $200,000,000, the amount of which, is in a great degree owing to the existence of steam navigation.

There were built in 1850, 161 steam vessels, and employed in trade in the United States, which are thus distributed in the various states:—Maine, 6; Massachusetts, 2; Vermont, 1; Connecticut, 1; Rhode Island, 1; New-York, 32; New-Jersey, 3; Pennsylvania, 31; Delaware, 1; Maryland, 4; Virginia, 5; North Carolina, 5; Georgia, 3; Louisiana, 4; Kentucky, 34; Missouri, 5; Illinois, 1; Ohio, 16; Michigan, 3; Texas, 1; Oregon, 2. Total 161. Which does not include those in the California trade, nor those lately put on Lake Nicaragua.

The subjoined chronological outline of the progress of steam will prove interesting:—

1663. The Marquis Worcester gave the first notion of a steam-engine.
1710. Newcomen (a barber) made the first engine.
1718. Savary first applied it.
1736. Steam navigation was first proposed.
1764. Watt made the first perfect English engine.
1778. T. Paine proposed to apply it to America.
1781. The Marquis Joffruy constructed a steam-vessel on the River Saone.
1782. Rumsey propelled a boat by steam at New-York.
1787. John Fitch navigated a boat on the Delaware.
1789. William Symington voyaged on the Clyde in a steam vessel. 1802. This was repeated.
1798. Oliver Evans, of Philadelphia, constructed a locomotive to travel on turnpike roads.
1807. Fulton made the first steam voyage from New-York to Albany at the rate of five miles per.hour in the *Clermont*.
1819. The *Savannah* steamer crossed from New-York to Liverpool, and thence to Russia.
1838. April 4th. The *Sirius* left Cork for New-York, arrived April 23d, steaming 161 miles a day.
1838. April 8th. The *Great Western* left Bristol for New-York, arrived April 23d, steaming 208 miles a day.

There are now (1851) regular lines of steamships established between New-York, Boston, and Philadelphia, on this side, and Liverpool, Southampton, Havre, and Bremen, in Europe. Up to 1838, the carriage of the mails, as well as of freight and passengers, between this country and Europe, was almost wholly confined to the New-York sailing-packets. From 1840 to 1850, the mails, and a large portion of the passengers, were monopolized by the English (Cunard) steamers. Steamships of other English companies were partially successful in this trade, but had all been withdrawn in 1850, when the American "Collins' line" of steamships, with the U. S. government contracts for carrying the mails, commenced running from New-York to Liverpool. The ships of this line are larger than those of the Cunard Company, and have proved themselves among the fastest ocean steamers afloat—two of them, the Baltic and Pacific, having crossed the Atlantic in 9 days and 13 to 20 hours. The dimensions of three of these vessels are as follow:

	Atlantic.	Pacific.	Baltic.
	Feet.	Feet.	Feet.
Length on deck	285	284	287
Breadth of beam...	45¼	45	45
Depth of hold......	32	32	32
Tonnage (Cust. H.).	2,771	2,686	2,718
——— (Carpenter's)............	3,040	2,900	2,920
Load draft.........	20	20	20
Diameter of cylinder	95 in.	95 in.	95 in.
Length of stroke ...	9 ft.	9 ft.	10 ft.
Nominal horse power of both engines	800	800	828
Diameter of paddle-wheels	35 ft.	36	36
Length of paddles..	12¼	11½	11½
Immersed midship section	725	720	720

The obvious peculiarity of these vessels is the absence of bowsprit and jib-boom. The cost of the Pacific is estimated at $575,000.

It is likely that, as far as the purposes of commerce are concerned, the use of the *screw propeller* will be yet generally adopted, and ultimately supersede paddle ships. It has some advantages over the paddle. The revolving screw was first applied by Archimedes as a power to raise water.

An important application of this form of screw has been made within these few years to steam navigation. An important use to which screw propellers have also been advantageously applied is as an auxiliary power for occasional use during calms and contrary winds for sailing vessels. The largest screw steamer constructed was the Great Britain, the burthen 3,000 tons, and the engines 1,000 horse power. It had a screw propeller 15½ feet in diameter, with six arms mounted in the stern, and capable of being turned with great rapidity. It was fitted afterwards with a stronger propeller, weighing several tons, and having four arms. In April, 1850, the first screw steamer started from Glasgow to New-York. An American Company are building them for the emigrant traffic from Liverpool to New-York.

A screw with an *increasing* pitch is generally preferable. By the word *pitch* is meant the distance between the threads of the screw. If the blades of the propeller are bent so as to be somewhat hollow, this makes it of an increasing pitch. The advantage of this shape is that each increasing portion of the screw overtakes the disturbed water, and so becomes effective. Woodcroft's screw, which is of this kind, was placed in the Great Britain before her last voyage. The Sarah Sands, now coasting along the Pacific, in the California trade, of 1,300 tons, has 2 oscillating engines, of 180 horse power, driving by direct action a Woodcroft's screw of 4 blades and 14 feet diameter. She reached New-York from Liverpool in 20 days, and returned in 14 days.

Commodore Skinner, in a late report, recommends the building of propellers by this government, and the French board have issued a similar recommendation.

All the new coasting vessels now being built in England, are propellers; and so many improvements have been made that they are now almost equal to the paddle steamers. The city of Philadelphia appears to be the great American port for building propellers.

A great feat was performed not long ago by a propeller built on the Clyde. The Admiral, a paddle steamer of 700 tons and 300 horse power engines, left Greenock for Liverpool, and was followed shortly after by the Arno, a screw propeller of 750 tons and 150 horse power, designed and built by Messrs. Wood and Reid, at Port Glasgow, and intended for the Mediterranean trade. The Admiral had a start of from two to three miles, and during the passage down the Clyde gained a little on her adversary, owing to a strong head-wind which prevailed. On getting into more open water, under a little alteration of the course of each vessel, the more ample spread of canvass by the screw boat told greatly on her speed and she gained considerably on the Admiral, and both went into Liverpool together. The Arno's engines attained a speed of 60 revolutions per minute. She carried 600 tons of coal, and the average speed was 14 miles per hour.

STEAM THRASHING MACHINE. Hitherto low pressure engines only have been applied to the thrashing machine; but Mr. Burstall has been lately engaged in introducing extensively the high pressure: 1st. Such engines are considerably cheaper in the original cost; 2d. they do not require more than 1-12th or 20th of the water which a condensing engine requires; and, 3d. a knowledge of their management is more easily acquired. They are thus rendered more fit for farm labor, and, when properly made, are as safe as atmospheric engines.

STEAM-ENGINE PLOUGHS have been invented and are extensively used in England, and in the Lowlands of Scotland, where labor saving machines are imperative.

STEAM-GAUGE. An instrument for indicating the pressure within a steam-boiler, by means of a bent tube partially filled with mercury, one end of which springs from the boiler, while the other is exposed to the air; so that the steam, by its pressure, raises the mercury in the straight limb of the tube to a height above the common level, proportioned to that pressure. An iron float and index are usually added for the convenience of observation.

STEAM-GOVERNOR. (*See* GOVERNOR.)

STEAM-GUN, or *Steam Generator.* Perkin's Steam Generator consists of a copper globe or cylinder, three inches thick, holding eight gallons, and competent to sustain an explosive action of 4000 lbs. to the inch. He heats this ball to a white heat, and forces the water into contact with the metal, so as to get steam with a pressure of 500 lbs. to the square inch. The valve bears 560 lbs., and the steam which flashes from it, as other water is injected, acts with a force exceeding 450 lbs. By flashes of this steam, passed through a gun-barrel, he projects balls with the force of gun-powder, and as rapidly as 100 in a minute, forming one of the most destructive missiles of war ever invented, and such as, if used, would soon put an end to all war. He asserts that more persons have been killed by *low* than by *high* pressure boilers in England, and that such has decidedly been the case in America.

It appears, by his experiments, that water does not approach the surface of red-hot iron at a white heat, and that it does not come into contact with the iron till after six evaporations, whose time varies from 90 to 12 seconds; but the seventh, which evaporates in 6 seconds, is in contact, and made in 6 seconds, and this he calls the evaporating point.

STEAM HAMMER of Mr. Nasmyth. The latest form of this instrument is that at Guest's Iron Works, Dowlais. The hammer or block of cast-iron which gives the blow to the iron on the anvil, is upward of six tons weight, with a clear fall of 7 feet perpendicular. The force is under control, and may be delicate or powerful as desired. It was originally made for welding bars of railroad iron by a few blows. The face of the hammer is 3 feet 9 inches long, by 2 feet wide, covering every part of the surface of the bloom at each blow—expressing every particle of cinder from the bloom, enhancing the quality and durability of the rail. The anvil of this mammoth hammer is supposed to be the largest casting in the world, being thirty six tons in a solid mass. This hammer is as extensively adopted in this country as in Europe. (*See* TILT HAMMER.)

STEAM, HEATING BY. It has been ascertained that one cubic foot of boiler will heat about 2000 cubic feet, 12½ feet each way, to an average heat of about 70° or 80° Fahr. And one square foot of surface of steam-pipe is adequate to the warming of 200 cubic feet, 6 each way. This quantity is adapted to a well-finished ordinary brick or stone building. Cast-iron pipes are preferable to all others for the diffusion of heat, the pipes being distributed within a few inches of the floor.

Steam is used extensively for drying muslin and calicoes. Large cylinders are filled with it, which, diffusing in the apartment a temperature of 100° or 130°, rapidly dry the suspended cloth. Experience has shown that bright dyed yarns, like scarlet, dried in a common stove-heat of 128°, have their color darkened, and acquire a harsh feel; while similar hanks, laid on a steam-pipe heated up to 165°, retain the shade and lustre they possessed in the moist state. Besides, the people who work in steam-drying rooms are healthy, while those who were formerly employed in the stove-heated apartments became, in a short time, sickly and emaciated. The heating, by steam, of large quantities of water, or other liquids, either for baths or manufactures, may be effected in two ways: the steam-pipe may be plunged, with an open end, into the water-cistern; or the steam may be diffused around the liquid in the interval between the wooden vessel and the interior metallic case. The second mode is of universal applicability.

Cooking food, both for man and cattle, is another useful application of steam: for it is the most effectual carrier of heat that can be conceived, depositing it only on such bodies as are colder than boiling water. Chambers filled with steam, heated to about 125° Fahr., have been introduced, with advantage, into medical practice, under the name of *Vapor-baths.*

STEARIC ACID, improperly called STEARINE, is the solid constituent of fatty substances, as of tallow and olive oil, converted into a crystalline mass by saponification with alkaline matter, and abstraction of the alkali by an acid. By this process, fats are convertible into three acids, called Stearic, Margaric, and Oleic; the first two being solid, and the last liquid. The stearine, of which the *adamantine* and *factitious wax* candles are made, consists of the stearic and margaric acids combined. These can be separated from each other only by the agency of alcohol, which holds the margaric acid in solution after it has deposited the stearic in crystals. Pure stearic acid is prepared, according to its discoverer, Chevreul, in the following way: —Make a soap, by boiling a solution of potash and mutton-suet in the proper equivalent proportions (*see* SOAP); dissolve one part of that soap in 6 parts of hot water, then add to the solution 40 or

50 parts of cold water, and set the whole into a place whose temperature is about 52° Fahrenheit. A substance falls to the bottom, possessed of pearly lustre, consisting of the bi-stearate and bi-margarate of potash; which is to be drained and washed upon a filter. The filtered liquor is to be evaporated, and mixed with the small quantity of acid necessary to saturate the alkali left free by the precipitation of the above bi-salts. On adding water to it afterwards, the liquor affords a fresh quantity of bi-stearate and bi-margarate. By repeating this operation with precaution, we finally arrive at a point when the solution contains no more of these solid acids, but only the oleic. The precipitated bi-salts are to be washed and dissolved in hot alcohol, of specific gravity 0·820, of which they require about 24 times their weight. During the cooling of the solution, the bi-stearate falls down, while the greater part of the bi-margarate, and the remainder of the oleate, remain dissolved. By once more dissolving in alcohol, and crystallizing, the bi-stearate will be obtained alone; as may be proved by decomposing a little of it in water at a boiling heat, with muriatic acid, letting it cool, washing the stearic acid obtained, and exposing it to heat, when, if pure, it will not fuse in water under the 158th degree of Fahrenheit's scale. If it melts at a lower heat, it contains more or less margaric acid. The purified bi-stearate being decomposed by boiling in water along with any acid, as the muriatic, the disengaged stearic acid is to be washed by melting in water, then cooled and dried.

Stearic acid, prepared by the above process, contains combined water, from which it cannot be freed. It is insipid and inodorous. After being melted by heat, it solidifies at the temperature of 158° Fahrenheit, and affects the form of white brilliant needles grouped together. It is insoluble in water, but dissolves in all proportions in boiling anhydrous alcohol, and on cooling to 122°, crystallizes therefrom in pearly plates; but if the concentrated solution be quickly cooled to 112°, it forms a crystalline mass. A dilute solution affords the acid crystallized in large white brilliant scales. It dissolves in its own weight of boiling ether of 0·727, and crystallizes on cooling in beautiful scales of changing colors. It distils over *in vacuo* without alteration; but if the retort contains a little atmospheric air, a small portion of the acid is decomposed during the distillation; while the greater part passes over unchanged, but slightly tinged brown, and mixed with traces of empyreumatic oil. When heated in the open air, and kindled, stearic acid burns like wax. It contains 3·4 per cent of water, from which it may be freed by combining it with oxide of lead. When this anhydrous acid is subjected to ultimate analysis, it is found to consist of—80 of carbon, 12·5 hydrogen, and 7·5 oxygen, in 100 parts. Stearic acid displaces, at a boiling heat in water, carbonic acid from its combinations with the bases; but in operating upon an alkaline carbonate, a portion of the stearic acid is dissolved in the liquor before the carbonic acid is expelled. This decomposition is founded upon the principle, that the stearic acid transforms the salt into a bicarbonate, which is decomposed by the ebullition.

Stearine is made, in this country, almost exclusively from lard, which furnishes about two-sevenths of its weight; the remaining five-sevenths being manufactured into lard oil.

Lime is the material used to saponify stearine, according to the old patent process of Gay Lussac, the celebrated French chemist; the process being effected by several hours' boiling, and the decomposition of the lime-soap is then effected by sulphuric acid.

The cakes of crude stearine—about 5,000 lbs. at a time—are then melted and saponified; the lime-soap decomposed; the stearine acid washed and cast into slabs or cakes of one by two feet in dimensions, and two inches thick. These are then pressed, cold, in powerful hydraulic presses, which squeezes out a portion of oleine—the red oil of commerce. They are pressed a second time in the hot presses, which are still more powerful than the others. They are afterwards steamed, drawn off into pans while hot, and bleached, strained through cloths into tin pans, and when it cools, forms blocks of a beautiful white wax appearance.

STEATITE (**SOAPSTONE**) is a mineral of the magnesian family. It has a grayish-white or greenish-white color, often marked with dendritic delineations, and occurs massive, as also in various suppositious crystalline forms; it has a dull or fatty lustre; a coarse splintery fracture, with translucent edges; a shining streak; it writes feebly; is soft, and easily cut with a knife, but somewhat tough; does not adhere to the tongue; feels very greasy; infusible before the blow-pipe; specific gravity from 2·6 to 2·8. It consists of—silica, 44; magnesia, 44; alumina, 2; iron, 7·3; manganese, 1·5; chrome, 2; with a trace of lime. It is found frequently in small contemporaneous veins that traverse serpentine in all directions, as in Shetland, in the limestone of Icolmkiln, in the serpentine of Cornwall, in Anglesey, in Saxony, Bavaria, Hungary, at Hoboken, N. J., and in Vermont. It is used in the manufacture of porcelain. It makes the biscuit semi-transparent, but rather brittle, and apt to crack with slight changes of heat. It is employed for polishing serpentine, marble, gypseous alabaster, and mirror glass; as the basis of cosmetic powders; as an ingredient in anti-attrition pastes; it is dusted in powder upon the inside of boots, to make the feet glide easily into them; when rubbed upon grease-spots in silk and woollen clothes, it removes the stains by absorption; it enters into the composition of certain crayons, and is used itself for making traces upon glass, silk, slabs for the sides and back of stoves, &c. The spotted steatite, cut into cameos and calcined, assumes an onyx aspect. Soft steatite forms excellent stoppers for the chemical apparatus used in distilling or subliming corrosive vapors. Lamellar steatite is TALC.

STEEL. This most useful and curious substance is a compound of iron and carbon: their relative proportions vary in steel of different qualities; but in that used for ordinary purposes, the carbon rarely exceeds 2 per cent., and is generally below it. Certain kinds of iron are preferred to others in this manufacture; but this relates entirely to its purity, which is the essential requisite. Steel is made by a process called *cementation*, which consists in filling a proper furnace with alternate strata of bars of the purest malleable iron and powdered charcoal: atmospheric air is carefully excluded from the boxes containing the bars, and the whole kept for several days at a red heat. By this process carbon, probably in the state of vapor, penetrates, and combines in the above small relative proportion with the iron, the texture of which, originally fibrous, becomes *granular*, and its surface acquires a *blistered* character. The malleability of steel falls far short of that of iron; but it is harder, and more sonorous and elastic, and susceptible of a higher polish, and has less tendency to rust. At a red heat it admits of hammering into various forms, and of being *welded* or united by the blows of the hammer to another piece of steel or iron. Blistered steel, rolled or beaten down into bars, forms *shear steel;* and if melted, cast into ingots, and again rolled out into bars, it forms *cast steel*, which, when well prepared, has the great recommendation of perfect uniformity of texture, and a finer and closer grain. The peculiarity of steel, upon which its high value in the arts in great measure depends, is its property of becoming, by sudden quenching in water, when at a bright red heat, extremely *hard*, and of being again *softened* down to any requisite degree by the application of a certain temperature, which may be indicated by a thermometer, commencing at about 300°, and terminating at a dull red heat. This process is often called *tempering;* and the workman is sometimes guided in the extent to which it is carried by the *color* of the polished surface of the heated steel, which is at first rendered by a pale straw tint, then yellow, brownish, purple, and blue, as the temperature rises from one extreme to the other. The latter color indicates extreme softness and elasticity, such as belongs to watch-springs, some sword-blades, &c.; pale straw indicates great hardness, as for razor blades; yellow is somewhat softer, and shows a fit temper for penknives; and the incipient blues announce the temper that belongs to coarser cutting instruments, and to table knives, any of which, made of hard steel, would soon get spoiled and notched, but the edges of which, when duly tempered, resist breaking on the one hand, and bending on the other. When a large mass of steel is hardened by quenching in water, it undergoes a certain degree of expansion, so that the specific gravity of hard steel is somewhat less than that of soft. It has been attempted to improve the quality of steel for certain purposes by adding to it a small portion of other metals: hence the term *silver steel*, &c.; but none of these alloys have on the whole proved superior to well made common steel. There is a kind of steel imported from India, known under the name of *wootz*, the cutting instruments of which are celebrated for the toughness and durability of their edge. It appears probable that its peculiarities depend upon the presence of a little aluminum. When the surface of some kinds of steel is washed over with a weak acid, it acquires a peculiar mottled or *damasked* appearance, as if its texture consisted of an intimate mixture of two different kinds of steel, or of fine fibres of steel and iron. Steel, alloyed with a little nickel, often puts on this appearance; but these and some other imitations of the celebrated *Damascus* sword-blades have not led to any important improvements in the manufacture of our cutting instruments.

The *Shear steel*, which derives its name from the accidental circumstance of the shears for dressing woollen cloth being usually forged from it, is made by binding into a bundle, with a slender steel rod, four parallel bars of blistered steel, previously broken into lengths of about 18 inches, including a fifth of double length, whose projecting end may serve as a handle. This faggot, as it is called, is then heated in the forge-hearth to a good welding-heat, being sprinkled over with sand to form a protecting film of iron slag, carried forthwith to the tilt, and notched down on both sides to unite all the bars together, and close up every internal flaw or fissure. The mass being again heated, and the binding rings knocked off, it is drawn out into a uniform rod of the size required. Manufacturers of cutlery are in the habit of purchasing the blistered bars at the conversion furnaces, and sending them to tilt mills to have them drawn out to the proper size, which is done at regular prices to the trade; from 5 to 8 per cent. discount being allowed on the rude bars for waste in the tilting. The metal is rendered so compact by the welding and hammering, as to become susceptible of a much finer polish than blistered steel can take; while the uniformity of its body, tenacity, and malleability, are at the same time much increased; by which properties it becomes well adapted for making table knives and powerful springs, such as those of gun-locks. The steel is also softened down by this process, probably from the expulsion of a portion of its carbon during the welding and subsequent heats; and if these be frequently or awkwardly applied, it may pass back into common iron.

Cast steel is made by melting, in the best fire-clay crucibles, blistered steel, broken down into small pieces of convenient size for packing; and as some carbon is always dissipated in the fusion, a somewhat highly converted steel is used for this purpose. The furnace is a square prismatic cavity, lined with fire-bricks, 12 inches in each side, and 24 deep, with a flue immediately under the cover, 8½ inches by 6, for conducting the smoke into an adjoining chimney of considerable height. In some establishments a dozen such furnaces are constructed in one or two ranges, their tops being on a level with the floor of the laboratory, as in brass foundries, for enabling the workmen more conveniently to inspect, and lift out, the crucibles with tongs. The ash-pits terminate in a subterraneous passage, which supplies the grate with a current of cool air, and serves for emptying out the ashes. The crucible stands, of course, on a sole-piece of baked fire-clay; and its mouth is closed with a well-fitted lid. Sometimes a little bottle-glass, or blast-furnace slag, is put into the crucible, above the steel-pieces, to form a vitreous coating, that may thoroughly exclude the air from oxidizing the metal. The fuel employed in the cast-steel furnace is a dense coke, brilliant and sonorous, broken into pieces about the size of an egg, one good charge of which is sufficient. The tongs are furnished at the fire end with a pair of concave jaws, for embracing the curvature of the crucible, and lifting it out whenever the fusion is complete. The lid is then removed, the slag or scoriæ cleared away, and the liquid metal poured into cast-iron octagonal or rectangular moulds, during which it throws out brilliant scintillations.

Cast steel works much harder under the hammer than shear-steel, and will not, in its usual state, bear much more than a cherry-red heat without becoming brittle; nor can it bear the fatigue incident to the welding operation. It may, however, be firmly welded to iron, through the intervention of a thin film of vitreous boracic acid, at a moderate degree of ignition. Cast steel, indeed, made from a less carburetted bar steel, would be susceptible of welding and hammering at a higher temperature; but it would require a very high heat for its preparation in the crucible.

Iron may be very elegantly plated with cast steel, by pouring the liquid metal from the crucible into a mould containing a bar of iron polished on one face. In this circumstance the adhesion is so perfect as to admit of the two metals being rolled out together; and in this way the chisels of planes and other tools may be made, at a moderate rate and of excellent quality, the cutting-edge being formed in the steel side. Such instruments combine the toughness of iron with the hardness of steel.

For correcting the too high carbonization of steel, or of equalizing the too highly converted exterior of a bar with the softer steel of the interior, the metal requires merely to be imbedded, at a cementing heat, in oxide of iron or manganese; the oxygen of which soon abstracts the injurious excess of carbon, so that the outer layers may be even converted into soft iron, while the axis continues steely; because the decarbonizing advances far more rapidly than the carbonizing.

To preserve steel from rust, Stodart's method is to wash with the ethereal solution of gold, or with muriate of platina. In this way, the breadths of polished steel in grates, fenders, &c., are preserved; and either may be purchased of chemists, or furnishing ironmongers.

Steel heated a little above the degree necessary to temper it, becomes soft, by that very operation of tempering, and this process, for nealing it, is much superior to the ordinary methods. The process in no way deteriorates the steel, and abridges the operation.

The *steel-hardening*, alluded to previously, is a very important process, in connection with steel-engraving and die-sinking. The subject is engraved on soft cast-steel, and then is hardened by placing it in a cast-iron pot, surrounded with animal charcoal. It is then exposed to intense heat of coke in an air-furnace, and afterwards placed in a vessel of cold water, renewed by a current. It is then used to make a puncheon-die on other soft steel, to be hardened, and this is a matrix for others, by which coin may be struck.

Every kind of iron is not suited to become steel. The iron which answers best is made at Danemora, in Sweden, and the whole produce of the Danemora mines, amounting to 8000 tons, is imported into Britain by a single house, and the cementation is performed at Sheffield, by Sanderson & Co., who export steel to all parts of the world.

For a long time we had to import all our steel from England, and England had to import all her iron from Sweden to make her steel. Within the past year steel has been made at the establishment of the Adirondac Steel Works in Jersey City, and although these works are comparatively in their infancy, having been in operation only since last January, the article produced is preferred, at the same price, for many purposes, to the best English cast steel. Similar works exist in Connecticut.

The ore used is produced from Essex county, N. Y., at the sources of the Hudson, at an altitude of 5,000 feet, among the Adirondac Mountains, and about 50 miles West from Lake Champlain. Large expenditures have been made by the proprietors for the purpose of developing the immense mineral resources of that region.

The ore is here converted into bar iron and transported to the Company's works in Jersey City to be manufactured into steel. Its adaptedness to this purpose was ascertained by Joseph Dixon, Esq., of Jersey City, after a protracted series of experiments made with reference to that object. He also succeeded in the use of anthracite—supposed by English manufacturers impossible; and then applied himself to the manufacture of black-lead crucibles possessing sufficiently powerful refractory qualities to withstand the heat of anthracite furnaces. In this too he was successful, and his pots are now in use in England and elsewhere by the first artisans.

In these, the steel is broken into small pieces, and put into sixteen crucibles of a capacity of forty to sixty pounds, which are placed in as many small furnaces whose tops are even with the surface of the floor. After the lapse of two hours, the molten contents are poured into ingot moulds, of various sizes. The steel is then readily drawn out upon being reheated, under heavy hammers, into bars of any desired shape or size.

Edge tools may be made with cast steel faces upon iron by fixing a clean piece of wrought iron, brought to a welding heat, in the centre of a mould, and then pouring in melted steel, so as entirely to envelope the iron, and then forging the mass into any shape required.

STEERING APPARATUS. An improvement on the steering wheel, as commonly used on shipboard. Capt. C. F. Brown, of Warren, Rhode Island, has invented a new and ingenious improvement in steering apparatus for vessels, for which he has taken measures to secure a patent, and which will, no doubt, arrest the attention of nautical men. The head of the rudder post is made of metal, with a helical groove running down on each side of it; and over this is placed a tube with two feathers on its inside, fitting into the said helical grooves. Over the top of this is another outside tube or cap, bolted by a flange to the deck, and on the top is the wheel, having for its axis a screw, which works into a thread opening in the second tube, and as the wheel is turned this second tube is raised or lowered, and its feathers, thereby working in the helical grooves of the head of the rudder post, turns it roundward and from one side to the other, thus operating the rudder and steering the vessel. The steering wheel is horizontal, and there is an indicating pointer on the post head, which, as it turns, points to an index, and enables the steersman to see every degree through which the rudder moves. Of all the steering apparatus that we have ever seen, this is the most compact and beautiful.

The steering apparatus on board the Cunard steamer Asia, which was invented by Messrs. Frazer and Robinson, R. N., differs from the foregoing. It consists in the application to the steering wheel of a friction band, similar to that used in cranes, which passes round a projecting circumference inside the wheel, and is brought down to a pedal on the deck, by pressure, on which any amount of friction can be put on the wheel. It is not desirable that the helm should ever be at a "dead lock," without the power of yielding a little to the shock of a very heavy sea, as that would endanger the carrying away the rudder. An adjusting screw is therefore provided, by which the amount of ultimate friction that can be put on the wheel is regulated, and not left in the power of the steersman. A great advantage of this invention is the power which it gives of fixing the rudders of vessels lying in the tideway or harbor, and thereby preventing the continual wear on the pintals of the rudder, and in time the loosening of the stern framing of the vessel.

STEELYARD. A balance by which the weights of bodies are determined by means of a single standard weight. In the Roman steelyard, or *statera*, the lever was so constructed that the centre of gravity was brought immediately over the point of support; and the system being accordingly balanced upon its fulcrum F, the effect of the weight of the lever was neutralized. The longer arm was then divided into parts, each equal to the shorter arm, and those again equally subdivided. Suppose now the length of the shorter arm, or the distance F B to be one inch, and the constant weight P to be one pound; then if P be placed at the distance of five inches from F, it will make equilibrium with a load of five pounds suspended from B; for, from the property of the lever, when the equilibrium is established the weight P is to the load at B as the distance of B from F is to the distance of P from F. Whatever proportion, therefore, F P has to F B, the same proportion has the weight suspended from B to the constant weight P.

The steelyard in common use is constructed somewhat differently, the beam being seldom made so as to balance itself on the fulcrum F; but the error that would arise on this account is compensated by beginning the divisions at that point where the weight P being placed, the equilibrium is established. If, therefore, when P is removed the longer arm preponderates, the divisions commence from a point between F and B. For the purpose of increasing the range, there are also in general two fulcra, from either of which the beam may be suspended, and two corresponding scales of division are marked on opposite sides of the longer arm.

For weighing heavy loads the steelyard is a convenient instrument; but for smaller weights it is susceptible of less accuracy than the common balance. It should be constructed so that the point of support F, and the point of suspension at B, may be in the same straight line with the divisions of the beam.

STENCILLING. Drawing upon walls in water colors, by means of a plate of metal, on which the device is cut out: a brush dipped in pigment, and passed over the plate, conveys the pigment through the perforations, and forms the pattern.

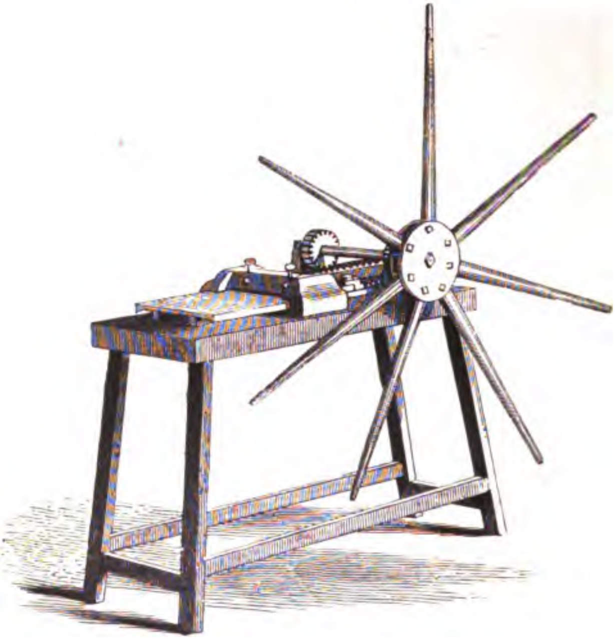
STEREOTYPING. The invention of stereotyping has usually been attributed in Europe to W. Ged, of Edinburgh, about 1780: but there is evidence on record that in 1779 Cadwallader Colden, of New-York, communicated the plan of the art to Dr. Franklin, then in Paris, and the details were by him given to Didot, the great printer. In 1780, Tillosh and Foulis introduced improvements: a little later, various novelties were added in France under the name of polytype. In some of them the form was imitated by striking upon a mass of soft metal like clichee moulds. Stereotyping, as now practised, became fully established in 1800. (See "*World's Progress*," p. 543.)

Stereotype printing signifies printing by fixed types, or by a cast typographic plate. This plate is made as follows:—The form composed in ordinary types, and containing one, two, three, or more pages, inversely as the size of the book, being laid flat upon a slab, with the letters looking upwards, the faces of the types are brushed over with oil, or preferably with plumbago (black lead). A heavy iron rectangular frame, with bevelled borders, adapted exactly to the size of the pages, is then laid down upon the chase, to circumscribe its typography. The frame resembles that of a picture, and serves to define the area and thickness of the cast, which is made by pouring the pap of Paris plaster into its interior space, up to a given line on its edges. The plaster mould, which soon sets, or becomes concrete, is lifted gently off the types by the untwisting of a screw at each corner, and immediately placed horizontally on shelves in an oven heated to 400°, when they become perfectly dry in two hours. As they are now friable and porous, they require to be delicately handled. Each mould, containing generally two pages octavo, is laid, with the impression downwards, upon a flat cast-iron plate, called the floating-plate; this plate being itself laid on the bottom of the dipping-pan, which is a cast-iron square tray, with its upright edges sloping outwards. A cast-iron lid is applied to the dipping-pan, which has its corners cut off to allow the melted metal to flow in, and is then secured in its place. The pan having been heated to 400°, by resting on the melted metal, previous to receiving the hot mould, is ready to be plunged into the bath of melted alloy contained in an iron pot placed over a furnace, and it is dipped with a slight deviation from the horizontal plane, in order to facilitate the escape of the air. As there is a minute space between the back or top surface of the mould and the lid of the dipping-pan, the liquid metal, on entering into the pan through the orifices in its corners, floats up the plaster along with the iron plate on which it had been laid, thence called the floating-plate, whereby it flows freely into every line of the mould, through notches cut in its edge, and forms a layer or lamina upon its face, of a thickness corresponding to the depth of the border. Only a thin metal film is left upon the back of the mould. The dipping-pan is suspended, plunged, and removed, by means of a powerful crane, susceptible of vertical and horizontal motions in all directions. When lifted out of the bath, it is set in a water-cistern, upon bearers so placed as to allow its bottom only to touch the surface. Thus the metal first concretes below, while, by remaining fluid above, it continues to impart hydrostatic pressure during the shrinkage attendant upon refrigeration. As it thus progressively contracts in volume, more melted metal is fed into the corners of the pan by a ladle, in order to keep up the hydrostatic pressure upon the mould, and to secure a perfect impression, as well as a solid cast. Were the pan more slowly and equably cooled, by being left in the air, the thin film of metal upon the back of the inverted plaster cake would be apt to solidify first, and intercept the hydrostatic action indispensable to the purpose of filling all the lines in its face. The lid of the pan being taken off, the compound cake of mould and metal is removed, and beat upon its edges with an iron sledge, to detach the superfluous metal. The stereotype plate is then washed with a brush and water to remove the adhering plaster, and handed over to the picker, who planes its edges truly square, turns its back flat upon a lathe, in which a steel cutter or knife, mounted on a slide rest, shaves off the metal in concentric circles to a determinate thickness, and carefully removes the little imperfections occasioned by dirt or air left among the letters when the mould was cast. Should any of them be damaged in the course of the operation, they must be cut out, and replaced by soldering in separate types of the same size and form.

They are then mounted on blocks of wood to the height of type.

In this country a machine, similar to that given in this illustration, is used for smoothing the back of the plate. This *Stereotype Shaving*, or *Planing Machine*, for equallizing the thickness of stereotype plates, is made of wrought and cast iron, and rests upon a wooden bench. It consists of a cast-iron bed plate planed perfectly true on the face and edges, with bearings projecting above to receive a wrought iron shaft with two case hardened pinions on it, between the bearings and a hand windlass, with arms outside, on one end. A sliding head, with knife attached, which can be adjusted by set screws, has two racks attached, by which it is impelled by the windlass and pinions back and forward over the stereotype plate (which is placed on the bed) until it is reduced to the required thickness.

STETHOSCOPE. A cylinder of cedar wood about 12 inches long, and 1 in



STEREOTYPE SHAVING, OR PLANING MACHINE. Page 608.

diameter; perforated throughout its length, having an ear-piece at one end and a funnel-shaped cavity at the other. It is used to recognize the sounds of the chest in health and disease.

STILE. In architecture, the vertical piece in framing or panelling.

STILL. An apparatus for the distillation of liquids upon the large scale. It includes the *body*, or *boiler*, which is usually set in brick-work over a furnace, and to which is annexed the *head*, forming the communication between the boiler and *condenser* or *worm-pipe;* from the extremity of which the distilled liquid passes in successive drops, or a small continuous stream, into the *recipient.* There are an infinite variety of stills adapted to particular purposes, of which the most important are the distillation of spirituous liquors.

STOMACH PUMP. A small pump or syringe with two apertures, the valves of which are so arranged as to admit of liquids being drawn out of, or injected into, the stomach, by means of a flexible tube.

STORAX. A gum-resin, obtained by incisions in the branches of a small tree which grows wild in the countries about the Mediterranean.

STOVE. A receptacle for the combustion of fuel for the purpose of heating houses, &c. The closed fire-grate for the combustion of coal, with its various appendages, is generally called a *stove*—hence *register stoves*, *Bath stoves*, &c. These are often, and indeed generally, very unscientifically constructed, and calculated to consume a large quantity of fuel, with a proportionate waste of heat. They are generally intended to diffuse warmth principally or entirely by *radiation*, and should be placed as near the floor as possible; while the different parts, into the contact of which the burning fuel is brought, should be of fire-brick, or some similar composition, which is a bad conductor, but a good radiator of heat. It is manifest that in open fire-places the enormous volume of hot air which passes up the chimney is not available as a source of heat; hence, in colder climates, such as that of the Northern States, and where greater economy of fuel is studied, the fireplace is frequently closed in, and contained in an iron box which projects into the room, while the heated air before it finally enters the chimney is made to circulate through tubes or pipes, to which it communicates much of its excess of heat, and these again impart it to the surrounding air. What are termed in Europe *German stoves*, are usually made upon such principles; and in them the fuel is often introduced, and the air required for the support of its combustion admitted, on the outside of the room in which the stove with its flues and heating surfaces is placed.

In *Arnott's stoves* the heat is similar, but more scientifically economized. There is only enough air admitted to keep up the slow combustion of the fuel, and the heat is communicated to the radiating surfaces of the stove; so that before the air, which has passed through the fuel, finally enters the chimney, it has been deprived of the greater part of its available heat. These stoves are also so constructed as, by means of thermometric or self-acting registers, to adjust with much nicety the supply of air, so that neither more nor less may enter than is required to maintain the combustion of a given quantity of fuel.

In *Feetham's air-stoves* the common open fire is retained; but the heat is to a certain extent economized by causing the hot air before it enters the chimney, to communicate a portion of its heat to an iron box, over which a current of air passes and is sent warm into the room.

It is manifest that open fires must act as powerful ventilators, and that the large quantity of air which is driven up the chimney must be supplied in some way or other through the apartment in which the fire is burning. This supply of air is generally left to chance, and finds its way into the room by crevices in the door-ways and window-sashes, or between the boards of the floor, or any similar accidental passage through which it can make its way; and as, in London at least, the air always abounds in fuliginous particles, these are carried in along with it, and show its track by the blacks which it deposits. If this supply of air is inadequate, and it generally is so in new and well-built houses, in consequence of the tightness of the doors, windows and floors, the chimney of necessity smokes, and the door or window requires to be left open to prevent such an effect. This evil may usually be effectually prevented by admitting fresh air from without through some proper and adequate channel, and various ornamental or concealed apertures may be contrived for the purpose; in the best arrangement of which, however, much practical as well as theoretical skill is often essential.

When rooms are warmed by German or Arnott's stoves, the ventilating powers of which are very inferior to the open grate, *ventilation* requires to be strictly attended to. Where buildings are warmed by currents of hot air sent up from stoves on the basement story, great attention should also be paid to ventilation; and in such cases the leading object should be to send in a large volume of air very moderately heated (to about 100°), rather than a small quantity of very hot air; the latter does not readily mix with the surrounding cold air, but forms a distinct and rapidly ascending column, which does not diffuse itself where most wanted; and is apt to have a disagreeable or burned odor, arising from the charring of the particles of organic dust, which are carried with the air over the too highly heated surfaces of the stove or flues. A little aqueous vapor, sent in along with the warm air by placing a saucer of water in some convenient situation, is often effectual in preventing the disagreeable sensation occasioned by respiring too dry an atmosphere.

The common Dutch stove is an iron box, of an oblong square form, intended to stand in the middle of a room. The air is admitted to the fire, through a small opening in the door, and the smoke passes off through a narrow funnel. Being insulated, and detached from the walls of the room, a greater part of the heat produced by the combustion is saved, and the radiated heat being thrown into the walls of the stove, they become hot, and, in their turn, radiate heat on all sides to the room. The conducted heat is also received by successive portions of the air of the room, which pass in contact with the stove.

The Swedish and Russian stoves are small furnaces, with a very circuitous smoke flue. In principle, they resemble a common stove, with a funnel bent round and round, until it has performed a great number of turns or revolutions, before it enters the chimney. It differs, however, in being wholly inclosed in a large box of stone or brick-work, which is intersected with air-pipes. In operation, it communicates heat more slowly, being longer in becoming hot, and also slower in becoming cold, than the common stove.

Russian stoves are usually provided with a damper, or valve, at top, which is used to close the funnel or passage, when the smoke has ceased to ascend. Its operation, however, is highly pernicious, since burning coals, when they are fully ignited, always give out carbonic acid in large quantities which renders the air of the room unfit for respiration.

The forms of stoves patented, and in use in this country, are so numerous, that it has been thought unnecessary to do more than advert to the general principles which should regulate their use.

STOVE. In horticulture, a structure in which plants are cultivated that require a considerably higher temperature than the open air in Britain and similar climates. There are two or three kinds of stoves, but the principal are the dry stove and the damp stove. The dry stove is a structure, the atmosphere of which is heated to the temperature of from 55° to 60° during winter, in which are chiefly cultivated succulents; such as the different species of *Ceretus*, *Cereus*, *Staphelia*, *Euphorbia*, *Mesembryanthemum*, and other succulents having similar habits. During winter these plants require very little water, and during summer they require intense heat, and abundance of air and water during fine weather. The damp stove, sometimes also called the bark stove, requires a temperature of between 60° and 70° during winter, with a proportionate increase during summer, accompanied, in both seasons, with a degree of atmospherical moisture. This moisture is produced partly by evaporation from the bark bed in which the plants are plunged, but chiefly by watering the floor of the house, and by syringing the plants. During summer the plants in the bark-stove require all the light which an unclouded atmosphere is capable of producing, together with abundance of air, as in the dry stove. Both stoves are heated by smoke flues, or by hot water or steam, circulated in metallic or other tubes. The plants cultivated in the moist stove are exclusively those of the tropics; and those which require the highest degree of heat are chiefly Monocotyledonous plants, such as the *Scitamineæ*, which include the ginger, plantain, banana, sugar cane, palms, *Orchidaceæ*; and such Dicotyledonous plants as the bread fruit, the yam, mangosteen, and other East Indian plants.

STRAW-HAT MANUFACTURE. In Italy the straw used for hats is made of rye, which is sown on poor land, very thick, and it therefore does not grow to above one half of its usual size. The rye straw used for braiding is cut near the ground when the grain is in the milk. It is tied up in small bundles, the heads cut off, and then it is dipped in boiling water, and put out to dry in the sun, taking care to take it in at night, and allowing no dew to get on it. When properly dried, it is cut into proper lengths, drawn between the fingers with a blunt knife edge along the inside, and is used either for fine or coarse bonnets, as is desired. The tool used for splitting straw is a piece of wood five inches long, with a series of sharp spurs near one end, with a wooden or metal spring over the spurs—or, rather, one side of them—which is pressed down upon the straw to keep it spread flat, while it is drawn over the spurs and split.

Straw is bleached by wetting it, and putting it into a tight box or barrel, with some sulphur placed on hot coals in an iron pot, placed on the bottom of it, so as to allow the straw to receive the free action of the sulphurous vapor. Two ounces of bar sulphur will bleach a pound of straw. The straw must be kept from the sides of the box, by laying it on strips of wood running across the box or cask. It should not be taken out of the sulphur box in less time than four hours. Old straw, leghorn, or palm-leaf hats or bonnets, may be whitened in this way, if they are thoroughly washed with a brush or sponge in soap-suds, before smoking. Straw must always be wet when it is braided, to prevent its breaking. The braiding and platting of straw is accomplished, in this country, by a straw platting machine, which is capable of braiding six plats. When the straw hats are dry, after being cleaned, they are sized with size made of clean parchment parings boiled in water, and then hung out to dry; and are afterwards pressed with clean damp cloths and hot irons, on blocks which fit them to the desired shape.

The mode of preparing the Tuscany or Italian straw is different from that made of rye, and is commenced by pulling the bearded wheat while the ear is in a soft milky state. The straw is spread out thinly upon the ground in fine hot weather, for three or four days, to dry the sap; it is then tied up in bundles and stacked, for the purpose of enabling the heat of the mow to drive off any remaining moisture. It is important to keep the ends of the straw air-tight, in order to retain the pith, and prevent its gummy particles from passing off by evaporation.

After the straw has been exposed about a month, it is removed to a meadow and spread out, that the dew may act upon it, together with the sun and air, and promote the bleaching. The first process of bleaching being complete, the lower joint and root is pulled from the straw, leaving the upper part fit for use, which is then sorted according to qualities; and after being submitted to the action of steam, for the purpose of extracting its color, and then to a fumigation of sulphur, to complete the bleaching, the straws are in a condition to be platted or woven into hats and bonnets, and are in that state imported in bundles, the dried ears of the wheat being still on the straw.

Straw may be bleached by a solution of chloride of lime. The straw, after being aired and softened by spreading it upon the grass for a night, is ready to be split, preparatory to dyeing. Blue is given by a boiling-hot solution of indigo in sulphuric acid, called *Saxon blue*, diluted to the desired shade; yellow, by decoction of turmeric; red, by boiling hanks of coarse scarlet wool in a bath of weak alum water, containing the straw; or directly, by cochineal, salt of tin, and tartar. Brazil wood and archil are also employed for dyeing straw.

STRENGTH. The power exerted by an animal or machine in overcoming resistance. That of the horse is used as a standard; it certainly is the most useful, and that whose labor is susceptible of the most numerous and varied applications. It is therefore very important to ascertain his average force; and accordingly a great number of estimates have been published, both of the amount of labor he is capable of performing, and of his absolute muscular power. For the purpose of determining the latter, the dynamometer may be conveniently used; but as the action of the animal is very quickly reduced by continued exertion, it is more usual to estimate it according to the amount of daily labor performed. Desaguliers and Smeaton estimate the strength of a horse as equivalent to that of five men; the French authors have commonly stated it as equal to that of seven men; and Schulze makes it equal to that of fourteen men in drawing horizontally. According to Desaguliers, a horse's power is equivalent to 44,000 lbs. raised 1 foot high in one minute; Smeaton makes this number 22,916; Hachette 28,000; and Watt 33,000. This last estimate is what is commonly understood by the term *horse power* as applied to steam engines.

The quantity of action which a horse can exert diminishes as the duration of the labor is prolonged. Tredgold gives the following table, showing the average maximum velocity with which a horse unloaded can travel, according to the number of hours per day:

Time of March, in Hours.	Greatest Velocity per Hour, in Miles.	Time of March, in Hours.	Greatest Velocity per Hour, in Miles.
1	14·7	6	6·0
2	10·4	7	5·5
3	8·5	8	5·2
4	7·3	9	4·9
5	6·6	10	4·6

The useful effect a horse is capable of producing, depends much on the manner in which his strength is applied. One of the best modes is to make him draw a loaded carriage. The carriers in Scotland usually transport in a single-horse cart, weighing about 7 cwt., the load of a ton, and travel at the rate of 22 miles per day. Neglecting the weight of the animal and of the cart, and supposing the journey to be accomplished in 10 hours, the useful effect reduced to dynamic units (1000 lbs. one foot in one minute) is 260,198 dynamic units.

Napier gives the following results: A horse, drawing in a cart a load of 1540 lbs., (700 kilogrammes,) travels at the rate of 216½ feet per minute, during 10 hours per day. Here the useful effect is 200,046.

A horse harnessed in a coach, and drawing a load of 770 lbs. avoirdupois, goes at a trot at the rate of 433 feet per minute, during 4½ hours per day. The useful effect is consequently 90,020.

A horse carrying on his back a load of 264 lbs. can travel at the rate of 216½ feet per minute, 10 hours a day. The useful effect is 84,294 dynamic units. Going at a trot with double the velocity, during 7 hours a day, and carrying a load of 176 lbs., the useful effect is 32,007.

A horse harnessed in a mill, going at a pace of 195 feet per minute, and exercising a force equal to a pressure of 99 lbs., during 8 hours a day, produces a useful effect represented by 9266 dynamic units.

On the strength of mules, oxen, and the other animals employed in industry, there are few correct observations. The following are the principal results: Taking the useful effect of the daily labor of a man according to Coulomb's estimate as unity, then the comparative effects of the labor of some of the other animals applied in the same manner are thus estimated:

For carrying loads in a horizontal plane—

Strength of a man	1	(Coulomb.)
" of a horse	4·8	(Brunacci.)
" of a horse	6 1	(Wesermann.)
" of a horse	7·6	(Brunacci.)

For transporting burdons with a wheel carriage—

Man with a barrow	1	Coulomb.)
Horse in a four wheel wagon	17 5	(Weserm.)
Horse with a cart	24 3	(Brunacci.)
Mule with a cart	23·3	(Brunacci.)
Ox with a cart	12·2	(Brunacci.)

The above comparisons are probably nearer the truth than the following, which are usually quoted from Hasseufratz (*Encyclopedie Methodique*):

In carrying loads on a horizontal plane—

Strength of a man	1
" of a horse	8
" of a mule	8
" of an ass	4
" of a camel	31
" of a dromedary	25
" of an elephant	147
" of a dog	1
" of a reindeer	3

In drawing a weight along a horizontal plane—

Strength of a man	1
" of a horse	7
" of a mule	7
" of an ass	2
" of an ox	4 to 7
" of a dog	0·6
" of a reindeer	0·2

STRENGTH OF MATERIALS. The force with which a solid body resists an effort to separate its particles, or destroy their aggregation, can only become known from experiment; nevertheless, if we assume an hypothesis to represent the manner in which the elementary particles are arranged and cohere, general formulæ may be deduced, which will represent the comparative strength of bodies of different forms and dimensions, or submitted to the action of forces applied in different manners, and will consequently be of great use in practical mechanics.

There are four different ways in which the strength of a solid body may be exerted: first, in resisting a longitudinal tension, or force tending to tear it asunder; secondly, in resisting a force tending to break the body by a transverse strain; thirdly, in resisting compression, or a force tending to crush the body; and fourthly, in resisting a force tending to wrench it asunder by torsion. We shall consider these separately.

1. *Longitudinal Tension.*—The resistance opposed by a solid body to a longitudinal strain is usually termed the *absolute strength*, or force of direct cohesion, of the body. Two points may be proposed for investigation: first, to determine the quantity by which a body of a given length is stretched or elongated under the action of a given force or weight; and secondly, the effect required to separate the parts or produce rupture. Experiments have usually been directed to the last of these only, but the first may be determined indirectly from experiments on flexure. In bodies of a fibrous structure, as the woods, the cohesive force differs greatly, according as the effect is applied in the direction of the fibres, or at right angles to it. When the strain is exerted in the direction of the fibres, the cohesive force obviously depends on two circumstances only—the strength of each fibre, and their number; and, in general, in bodies of the same substance and structure, the strength is proportional to the transverse area of the body, and to a certain constant which must be determined by experiment.

Although the longitudinal tension is, with respect to mechanical action, the simplest of all the strains to which a solid body can be subjected, it is the most difficult to submit to experiment, by reason of the enormous forces required to produce rupture, and, in the case of fibrous bodies, the difficulty of applying those forces in the direct line of the fibres. If the fibres are not all subjected to the same strain, it is obvious that the direct cohesion will be estimated at less than its real value; and, as Mr. Barlow remarks, it is probably owing to this circumstance that so little agreement is found in the results of experiments.

2. *Transverse Strength.*—When a body suffers a transverse strain, the mechanical action which takes place among the particles is of a more complicated nature. Galileo was the first who attempted to give a rational explanation of this action, and to submit the strength of the materials used in the mechanical arts to the measures of geometry and arithmetic. He assumed that all solid bodies are composed of numerous small parallel fibres, perfectly inflexible and inextensible; and that when they break, the several fibres give way in succession, the body turning on the last, which give way as on a hinge, and the strain on each fibre, previous to the rupture, being proportional to its distance from the quiescent fibres.

From the table of *data* given by Barlow the following mean results of experiments (on beams supported at both ends), made in the dock-yard at Woolwich, for determining the elasticity and strength of various species of timber, are extracted:

Description of Wood.	Elasticity. $E=\frac{w\,l^3}{32h\,b\,d^3}$	Strength. $S=\frac{W\,l}{4\,b\,d^2}$
Teak............	301800	2462
Poon............	211300	2221
English Oak......	109200	1181
Ditto, another spec.	181400	1672
Canadian Oak.....	262600	1766
Ash	205600	2026
Beech...........	169200	1556
Elm.............	87480	1013
Pitch Pine........	153300	1632
New-England Fir..	273900	1102
Riga Fir..........	166100	1108
Mar Forest Fir....	108700	1262
Larch	131600	1149
Norway Spar.....	182200	1474

From the mean of a number of experiments by Tredgold, the values of E and S, for rectangular cast iron bars, were found to be E=2254000, S=7620.

Resistance of bodies to forces tending to crush them.—The resistance of a body to a crushing force might be supposed, *a priori*, to follow the same law as the absolute force of cohesion, and, consequently, to depend only upon the area of the section and the force of aggregation of the particles. It is found, however, by experiment, that the thickness of the body (or length, if the force is applied endwise), has an important influence on the amount of pressure it is capable of bearing. Very thin plates are readily crushed; and the resistance appears to increase with the thickness up to a certain maximum, after which it diminishes. The theory of the resistance of pillars, which is of great importance on account of its application to architectural purposes, was investigated by Euler; and, according to the hypothesis adopted by him, the strength varies directly as the fourth power of the diameter or side, and inversely as the square of the length. This is confirmed by the recent experiments of Mr. Hodgkinson, in respect of pillars of wrought iron or timber; but in the case of pillars of cast iron, the powers of the diameter and length were somewhat different. Mr. Hodgkinson found from a mean of experiments, that a solid, uniform pillar of cast iron, whose transverse section is one square inch, is destroyed by a weight of 98922 lbs., or 44·16 tons. Assuming this as a unit of measure, he gives the following formula (as representing his experiments), in which *s* is the strength or weight in lbs. that would crush the pillar, *d* the diameter, and *l* the length, viz., $s—98922 \times d^{3·55} \div l^{1·7}$. This formula applies to pillars of which the lengths are twenty-five times the diameter and upwards, and which are perfectly flat at the ends. When the ends of a pillar are rounded, so that the load bears only on the middle fibres, the strength is greatly reduced. In pillars whose length is thirty times the diameter, or upwards, Mr. Hodgkinson found the strength of those with flat ends to be about three times greater than the strength of others of the same dimensions with round ends, the mean ratio being 3·167. In shorter pillars the ratio was not constant. The strength of a pillar is slightly increased by placing disks on the ends to increase the bearings.

STRONTIA, one of the alkaline earths, of which *strontium* is the metallic basis, occurs in a crystalline state, as a carbonate, in lead mines. The sulphate is found crystallized in several parts of the world; but strontitic minerals are rather rare. The pure earth is prepared, like baryta, from the carbonate or the sulphate. It is a grayish-white powder, infusible in the furnace, of a specific gravity approaching baryta, having an acrid, burning taste. It becomes hot when moistened, and slakes into a pulverulent hydrate, dissolves in 150 parts of water at 60°, and in much less at the boiling point, forming an alkaline solution called *strontia* water, which deposits crystals in four-sided tables as it cools. These contain 68 per cent. of water, are soluble in 52 parts of water at 60°, and in about 2 parts of boiling water; when heated they part with 53 parts of water, but retain the other 15 parts at a red heat. The dry earth consists of 84·55 of base, and 15·45 of oxygen. It is readily distinguished from baryta, by its inferior solubility, and by its soluble salts giving a red tinge to flame, while those of baryta give a yellow tinge. Fluosilicic acid and iodate of soda precipitate the salts of the latter earth, but not those of the former. The compounds of strontia are not poisonous, like those of baryta. The only preparation of strontia used in the arts is the NITRATE. (*See* PYROTECHNY.)

STRYCHNIA. A poisonous vegetable alkaloid, discovered in 1818 by Pelletier and Caventou in the seed of the *Strychnos ignatia* and *Nux vomica*, and also in the upas poison. It is almost insoluble in water, but very soluble in boiling alcohol, from which it is deposited by careful evaporation in small white crystals. It is so virulently poisonous, that half a grain blown into the throat of a rabbit occasioned death in five minutes; its operation is accompanied by lock-jaw and other tetanic affections. The chemical equivalent of strychnia is about 238. It probably consists of 30 atoms of carbon, 16 hydrogen, 3 oxygen, and 1 nitrogen.

STUBBLE. The root ends of stalks of grain left in the field standing as they grow after the grain has been reaped by the sickle or scythe. In some parts of the country only a small portion of the straw is cut off with the ears, and the stubble in that case is a foot or eighteen inches in length; but in others the grain is cut as close to the surface as possible, in which case the stubble is quite short. In general, long stubble is objectionable, as the straw is in this case left waste in the field, which might have been carried home and rotted into manure. It may, however, be turned into the ground.

STUCCO. In architecture, a term applied to many sorts of calcareous cements. The sense in which it is most commonly used in this country is to denote the third coat of three-coat plaster, consisting of fine lime and sand. The better sort is hand-floated twice and well trowelled. There is a species called bastard stucco, in which a small portion of hair is used. Rough stucco is merely floated and brushed with water, but the best is trowelled stucco.

SUBERIC ACID. An acid substance into which cork is converted by the long-continued action of nitric acid.

SUBERIN. A name given by Chevreul to the cellular tissue of cork after the various soluble matters have been removed by the action of water and alcohol.

SUBLIMATION. A process by which solids are by the aid of heat converted into vapor, which is again condensed, and often in the crystalline form. This operation is frequently resorted to for the purpose of purifying various chemical products, and separating them from substances which are less volatile.

SUBSTANTIVE COLORS, are those which, in the process of dyeing, remain fixed or permanent without the intervention of other substances; they are opposed to *adjective colors*, which require to be fixed by certain *intermedia*, or substances which have a joint affinity for the coloring matter and the material to be dyed. (*See* Dyeing and Mordant.)

SUBSTRATUM. A stratum lying under another. The term *subsoil* is generally applied to the matters which intervene between the surface soils and the rocks on which they rest; thus clay is the common substratum or subsoil of gravel.

SUGAR, is the sweet constituent of vegetable and animal products. It may be distinguished into two principal species. The first, which occurs in the sugar-cane, the beet-root, and the maple, crystallizes in oblique four-sided prisms, terminated by two-sided summits; it has a sweetening power which may be represented by 100; and in circumpolarization it bends the luminous rays to the right. The second occurs ready formed in ripe grapes and other fruits; it is also produced by treating starch with diastase or sulphuric acid. This species forms cauliflower concretions, but not true crystals; it has a sweetening power which may be represented by 60, and in circumpolarization it bends the rays to the left. Besides these two principal kinds of sugar, some others are distinguished by chemists; as the sugar of milk, of manna, of certain mushrooms, of liquorice-root, and that obtained from saw-dust and glue by the action of sulphuric acid; but they have no importance in a manufacturing point of view.

Sugar, extracted either from the cane, the beet, or the maple, is identical in its properties and composition, when refined to the same pitch of purity; only that of the beet seems to surpass the other two in cohesive force, since larger and firmer crystals of it are obtained from a clarified solution of equal density. It contains 5·3 per cent. of combined water, which can be separated only by uniting it with oxide of lead, into what has been called a saccharate; made by mixing syrup with finely ground litharge, and evaporating the mixture to dryness upon a steam-bath. When sugar is exposed to a heat of 400° F., it melts into a brown pasty mass, but still retains its water of composition. Sugar thus fused is no longer capable of crystallization, and is called caramel by the French. It is used for coloring liquors. Indeed, sugar is so susceptible of change by heat, that if a colorless solution of it be exposed for some time to the temperature of boiling water, it becomes brown and partially uncrystallizable. Acids exercise such an injurious influence upon sugar, that after remaining in contact with it for a little while, though they be rendered thoroughly neutral, a great part of the sugar will refuse to crystallize. Thus, if three parts of oxalic or tartaric acid be added to sugar in solution, no crystals of sugar can be obtained by evaporation, even though the acids be neutralized by chalk or carbonate of lime. By boiling cane sugar with dilute sulphuric acid, it is changed into starch sugar. Manufacturers of sugar should be, therefore, particularly watchful against every acidulous taint or impregnation. Nitric acid converts sugar into oxalic and malic acids. When one piece of lump sugar is rubbed against another in the dark, a phosphorescent light is emitted.

Sugar is soluble in all proportions in water; but it takes four parts of spirits of wine, of spec. grav. 0·830, and eighty of absolute alcohol, to dissolve it, both being at a boiling temperature. As the alcohol cools, it deposits the sugar in small crystals. Caramelized and uncrystallizable sugar dissolve readily in alcohol. Pure sugar is unchangeable in the air, even when dissolved in a good deal of water, if the solution be kept covered and in the dark; but with a very small addition of gluten, the solution soon begins to ferment, whereby the sugar is decomposed into alcohol and carbonic acid, and ultimately into acetic acid.

SUGAR, MANUFACTURE OF. The great commercial demand for sugar is almost exclusively supplied from the sugar cane (*Arundo saccharifera*), which contains it in greater quantity and purity than any other plant, and consequently affords the greatest facilities for its extraction. A large quantity of sugar is contained in the sap of the American maple (*Acer saccharinum*), and in the juice of the beet-root (*Beta vulgaris*), from both of which it may be economically obtained; it has also been extracted from grapes or raisins, and, as is well known, is contained abundantly in many ripe fruits and esculent vegetables. It is, however, in these, seldom so pure or in such quantity as to admit of ready separation.

Sugar is a crop, which, as made from the cane, is almost confined to Louisiana, in this country. The return of the crop

of 1846, was about 140,000 hogsheads. In the year 1848, the growth being larger, it was estimated at 240,000—which at the rate of 50 dollars a hogshead, would give the sum of 12,000,000 dollars, the value of a single product of 23 parishes in that State. The cultivation of this plant is extending in Georgia, Alabama, and Florida. Texas, however, will be the greatest rival of Louisiana in the cultivation.

The steady advance in improvement of Louisiana, affords encouragement to believe, that the time may not be far distant, when this State, aided by Florida and Texas, will be able to furnish enough to meet all the demands for consumption of this article in the United States. This would be a very desirable consummation, not merely on account of the growing prosperity of this State, but as occasioning still increased exchange of products from other States.

The following, taken from the New Orleans Price Current, of September 1, 1847, as the amount of the crops of that State for many years past:

Crop of	1828	88,000	hhds.
"	1829	48,000	"
"	1832	70,000	"
"	1833	75,000	"
"	1834	100,000	"
"	1835	30,000	"
"	1836	70,000	"
"	1837	65,000	"
"	1838	70,000	"
"	1839	115,000	"
"	1840	87,000	"
"	1841	90,000	"
"	1842	140,000	"
"	1843	100,000	"
"	1844	200,000	"
"	1845	186,000	"
"	1846	200,000	"
"	1847	240,000	"

The production and consumption of sugar is large. In 1844, the whole amount produced from all the sugar-growing countries in the world was set down at 778,000 tons, of which 200,000 was supplied by Cuba alone. It is probable that by this time, therefore, it can scarcely be less than 850 to 900,000 tons, if we include beet and maple sugar. It is estimated that Great Britain consumes as much as 250,000 tons, the rest of Europe 450,000, the United States 150 to 160,000 tons, or more; Canada and the other British Colonies, 25,000 tons.

The amount of *beet-root sugar* made in France in 1846–1847, was estimated at 107,190,110 pounds, being an increase of 26,596,432 pounds on the quantity manufactured the previous year. This article shows the importance of perseverance in such experiments as hold out the probability of success. It is well known, as a fact of history, that the origin of this manufacture as a national one, sprung from the necessities of the French people, when in their wars, they were cut off from the usual supplies of cane sugar by the West Indies. It is not less, too, a matter of record, how great was the ridicule cast upon the Emperor Napoleon for his efforts by way of encouragement to this business.

Five different kinds of cane are cultivated in Louisiana—Bourbon, green-ribbon, red-ribbon, Otaheite, and creole. The two first are the most extensively cultivated. The cane is planted in fall, sometimes in October, in rows from five to eight feet apart, and reaches its full growth in nine months. It grows so luxuriant that the rays of the sun cannot penetrate it. Previous to planting, the soil is ploughed, harrowed, and the furrow opened with a double mould-board plough. Cane slips are then laid in straight lines three thick, and overlapping. They are then covered four or six inches with earth, as a protection from frost.

The Mississippi lands on which the cane grows is almost inexhaustible, requiring no manure for the present but only to be ploughed deeper. It is found, however, advantageous to plough in the tops and other refuse matter of the cane. On this point, Mr. Benjamin, writing in De Bow's Review, says:

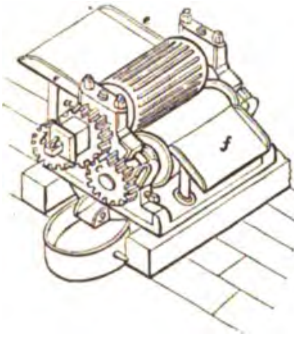
"When the cane is cut in the fall, a large portion of the produce of the soil remains on the field, as is well known, in the tops and leaves of the cane, the ripe portion alone of the stalk being conveyed to the mill. This is called the trash, and is placed on the stubble to assist in protecting from the frost that part of the cane which remains under ground, and from which the rattoons shoot up the ensuing season. As soon in the spring as danger of frost is no longer apprehended, the trash is raked off the rows of stubble to allow access to the sun and air; and on nearly all plantations this trash, which is a useful and fertilizing manure, is burnt up, instead of being returned to the earth. One cause of the difficulty of making use of this trash as manure, was the narrowness of the space between the rows under the old system of planting, which left so little room as to make the operation of ploughing in the trash difficult and laborious; but where the rows are eight feet apart, the task is easy. Independently of the considerations to which I shall presently advert, and which derive their force from the chemical constitution of the cane, it is difficult for a person who has not witnessed the results to form an adequate idea of the improvement to a soil that is naturally at all stiff or clayey, from the mere mechanical subdivision of its particles attendant on the decay of the large quantity of this trash left annually in the fields. This system was first put into operation last year on the plantation of which I am part owner."

When the canes are ripe, they are cut and sent to the crushing-mill to separate the juice.

The mills used for grinding the cane are generally placed 10 to 12 feet from the ground, in order to give sufficient fall for the juice to flow into the juice-boxes, and from them into the kettles.

The mills consist mostly of three iron rollers, from 25 to 28 inches in diameter, and from 4 to 5½ feet long.

The following cut is an illustration of a horizontal sugar-mill.



The thickness of the shell of the rollers, in those mills constructed by Leeds & Co., New Orleans, varies from 2½ inches to 3 inches, according to size; the depth of the eye of the roller is 12 inches in all these mills. The shafts are of wrought iron. The journals vary in size from 7½ to 8½ inches in diameter. The boxes in which the journals revolve are of brass, lined with "Babbitt's anti-attrition metal." The return plats, about which there is a great difference of opinion respecting their proper position, are placed from 1 to 2 inches below the top roller. The cane carrier is from 50 to 90 feet in length, according to the height at which the mill is placed.

Planters who pay attention to the setting of the rollers and the feeding of the cane carrier, obtain 66 per cent. of juice; yet the usual amount obtained, probably, does not exceed 52 per cent. Wray recommends "the first under roller to be adjusted exactly five-sixteenths of an inch from the main or upper roller, and the second under roller just one-tenth of an inch from the upper roller."

The juice so obtained, is carefully evaporated till it has acquired the proper consistency for crystallizing; lime water is added during this operation, to neutralize any free acid, and to facilitate the separation of certain vegetable matters, which, in consequence of the action of the lime, rise more readily to the surface, and admit of being skimmed off. When duly concentrated, the syrup is run off into shallow wooden coolers, where it concretes; it is then put into barrels with holes in the bottom, through which a quantity of treacle or molasses gradually drips, and the remaining sugar acquires the granular crystalline state; it is packed into hogsheads, and comes to us under the name of *raw* or muscovado sugar.

The following is a sketch of the process by which raw sugar is purified. Raw sugar is chosen by the refiner by the sharpness and brightness of its grain; it is put into a copper pan or boiler, previously charged with a certain quantity of lime-water, with which a portion of bullock's blood has been well mixed by agitation, and is suffered to stand a night to dissolve. Early in the morning fires are lighted under the pans, and when the liquid boils, the coagulated albumen of the blood rises to the surface and carries the impurities of the sugar with it. The liquid is kept gently simmering, and continually skimmed, till a small quantity, taken out in a metal spoon, appears perfectly transparent: this generally takes from four to five hours. The clear syrup is then run off into a cistern; the pans are reduced to half their former size. by taking off a movable front, and a smaller portion of the purified syrup returned into each; the fires are now increased, and the sugar made to boil as rapidly as possible, till a small quantity taken on the thumb is capable of being drawn into threads by the forefinger; the fire is then damped, and the boiling syrup carried off in basins to the *coolers*; a fresh quantity is then pumped into the pans and evaporated as before. In the coolers the sugar is violently agitated with wooden oars till it appears granulated. It is upon this agitation that the whiteness and fineness of grain in the refined sugar principally depend; the crystals are thus broken down while forming, and the whole converted into a granular mass, which permits the colored liquid saccharine matter to run off, and which would be combined with the solid if it were suffered to form into larger crystals. This granular texture likewise facilitates the percolation of water through the loaves in the after process, which washes the minutely divided crystals from all remaining tinge of molasses. That this is the real theory of the whitening of sugar by the process of refining, appears from a comparison with the process for making *sugar candy*. In this the raw material is cleared and boiled as above; but instead of being put into coolers and agitated, it is poured into pans, across which threads are strung, to which the crystals attach themselves; these are set in a stove, and great care is taken not to disturb the liquid, as upon this depends the largeness and beauty of the candy. In this state it is left for five or six days exposed to a heat of about 95°; when it is taken out and washed with lime-water. This takes off the molasses from the outside; but a great quantity is combined in the crystal, and the consequence is, that candy is never whiter than the sugar it is made from. When the sugar has attained the granular state in the coolers, as above described, it is poured into conical earthen moulds, which have been previously soaked a night in water; in these it is again stirred, for the purpose of extricating the air-bubbles, which would otherwise adhere to the surface and render it rough; when sufficiently cold, the loaves are carried to some of the upper floors of the manufactory, and the paper covers being removed from their points, they are set with their broad ends upward upon earthen pots. The first portions of the liquid molasses soon run down, and leave the sugar much whitened by the separation; afterwards, pipe-clay mixed with water to the consistency of cream is put upon the base of the loaves to the thickness of about an inch; the water from this clay filters through the loaf, and carrying with it all remaining tinge of molasses, runs into the pot, the clay being of no other use than to retain the water and prevent its too rapid percolation, by which too much of the solid sugar would be dissolved. This process, called *claying*, is repeated four or five times, according to the nature of the sugar and the degree to which it has been boiled. When the loaves are thus cleansed from all relics of color they are suffered to remain some time for the water to drain off; when this is completed, they are set with their points upwards, when all remains of it are equally diffused throughout; they are then *stove-dried* at a temperature between 95 and 100.

Mr. M. Robinson has patented some improvements in the process of making and purifying sugars. He applies to the juice a saturated mixture of alum and lime, in the proportion of two pounds of the mixture to a hundred gallons of the juice. These being intimately mixed, the acid is to be neutralized by the application of milk of lime, in the proportion of three pounds to a hundred gallons. If there be an excess of acid, it will be discovered by the application of the test-paper usually employed by chemists to detect acids, and more milk of lime must be added: and if there be an excess of alkali, it may be discovered by the application of the test-paper used for detecting alkalies, and more juice must be added. When the mixture ceases to affect either the test for acid or alkali, the impurities will be precipitated, and may thus be separated; and the juice thus purified is to be subjected to the usual mode of clarification and concentration.

Pure raw sugar is now obtained direct from the sugar-cane, without having undergone any subsequent process of decolorization or refining, prepared by effecting the last stages of the concentration of the cane-juice in a vacuum, at a temperature insufficient to produce any chemical changes in its constituent parts. By this improved and scientific process of manufacture, no molasses, or uncrystallizable sugar is formed, and there is, hence, an increase in the quantity of sugar obtained of 25 per cent. This establishes the fact, that molasses is not an *educt* of the cane, but merely a product of the former operation, from the intense and long continued degree of heat employed in the processes. The sugar, thus obtained, is in perfect, pure, transparent, granular crystals, developing the true crystalline form of the sugar, and being entirely free from the least portion of uncrystallizable sugar or coloring matter. The new process is now in complete and successful operation in eight estates in

Demerara. From the results of the first trials, the introduction of the present improved process cannot fail soon to become general, and the product is much approved in the European market.

Instead of open kettles and pans, high-pressure steam, and vacuum pans have been introduced, producing an economy in the manufacture. Different forms of steam apparatus are used in different places—such as that of Derosne, Degrand, and Zélieux.

The process of potting sugar, or freeing it from syrup or treacle, (molasses,) as practised in the West Indies and other countries, consists in allowing it to stand for a considerable period of time in hogsheads, casks, or cisterns, having holes bored through their bottoms. The force of gravity causes the syrup or treacle gradually to descend through the sugar, and escape through the holes in the bottom of the hogsheads.

In order, by the above operation, to expel the syrup or liquid sufficiently to render the sugar fit for market, much time is necessarily consumed. Besides, large curing-houses, as they are termed, adapted for the purpose must be erected and maintained. An improvement made, consists in effecting the separation of molasses, by a machine of a peculiar construction, which accomplishes the same through the agency of *centrifugal force.*

The objects of boiling and evaporating juice is to separate extraneous matters. The addition of blood and lime have for their object, the one to entangle, the other to neutralize the thick and acid impurities, and ultimately separate them from the syrup. Charcoal or ivory black is used to remove coloring matter. Dr. Scoffern's new process dispenses with the use of lime and blood. It is based on the affinity of oxide of lead for coloring matter, as well as for the melacic and other acids, all of which have to be removed from the syrup. Dr. S. heats the syrup 250° Fahr., and then mixes it with subacetate of lead; a bulky precipitate of melacitate of lead, formed with syrup more or less contaminated with lead, passes through the filter. This lead is then separated in the form of an insoluble sulphate by a current of sulphurous acid sent through the syrup. After the removal of the metal has been proved by the test of sulphuretted hydrogen, chalk is added to neutralize the acetic acid, and then the syrup is thus sent to the vacuum pan for granulation.

The latest improvement in the purification of sugar is that of M. Melsens of Belgium. This chemist employs acid sulphites, more especially bi-sulphite of lime, for the double purpose of preventing fermentation by the action of the sulphurous acid, and of neutralizing the sulphuric acid as fast as it is formed by means of the lime. The results are, that bi-sulphate of lime can be employed in the extraction of sugar as an antiseptic, preventing the production and action of any ferment—and as a substance greedy of oxygen opposing an alteration which its action on the juice could effect. It also acts as a *clarifier*, coagulating at 212° all albuminous and other coagulable matters. It also bleaches all coloring matters, and prevents their after formation; and it is alone capable of neutralizing any acids which exist or may be formed in the juice. The quantity of sugar which is now lost in the bagasse, in consequence of the impossibility of washing it out unchanged, can be all collected by being dissolved in water charged with bi-sulphate of lime. Both M. Melsens's and Dr. Scoffern's processes are liable to objections; but, even as they stand, they are large improvements in the manufacture. In the preparation of beet sugar, bi-sulphate of lime is said to be as valuable as for the cane. In this manufacture, M. Melsens employs a solution of bi-sulphate of lime, of 10° Beaume; the beet-root pulp is sprinkled over with this solution; 24 parts of bi-sulphate are sufficient for 100 parts of beet-root. The saccharine solution marking 7° or 8° Beaume when it comes from the press, remains almost colorless when exposed to the air, and does not ferment. It is then heated, without any further addition, up to 100° C., and as soon as it boils, it is run off and filtered; the limpid juice is then evaporated to 30° Beaume,—filtered a second time, concentrated to the required degree, and then set aside to crystallize.

M. Chevreul states, in reference to the above process, that the employment of sulphites cannot be claimed as a new discovery. M. Lacoste, in 1809, employed sulphurous acid; and M. Proust, in 1810, the sulphite of lime. M. de Bournissac, a prisoner in the fortress of Vincennes, was set at liberty in consideration of his work on the employment of these substances in the manufacture of sugar from the grape; and MM. Poulet of Marseilles, Serullas, Dejardin, and Fournier, junr., of Nismes, have published accounts of their researches on this subject.

Process of M. Dubrunfaut.—M. Dubrunfaut employs hydrate of baryta, which separates the sugar from the principal part of the salts and foreign matters contained in the pulp; the insoluble saccharate of baryta is then treated with sulphuric acid, and a perfectly pure sugar is obtained.

The following is one of the most recent methods for the manufacture of maple sugar (*see* MAPLE), as given by S. Tinker, of Richland, Oswego co., N. Y. The sap is boiled in a potash and caldron kettle to a thick syrup, strain it when warm, let it stand 24 hours to settle, then pour it off, heaving back all that is impure. To clarify 50 pounds, take a quart, one ounce of saleratus, and the whites of two eggs well mixed. Boil it again until hard enough to lay upon a saucer, then let it stand in the kettle till cool; stir it very little, to keep it from caking in the kettle, or draining, use a tube funnel-shaped, say 15 inches square at the top, coming to a point at the bottom. Put in the sugar when cold, tap it at the bottom, and keep a flannel cloth damp on the top two or three thicknesses. When drained, dissolve the sugar in pure warm water and clarify, and drain it as before. It is impossible to estimate the amount of maple sugar produced. The season exercises a remarkable influence, and the increased cutting of timber in a district annually lessens the crop. The low price of imported sugar also tends to keep down its manufacture.

It is but a few years since the highest reach of art in this manufacture produced only a fine muscovado-like sugar, and now, by the improved processes, specimens are annually exhibited at the agricultural fairs, vying with the most beautiful loaf sugar. This has been effected by great attention to cleanliness in the preparation of the sap, and in the processes of purification and graining.

The manufacture of sugar from *beet* deserves more attention than it has received in this country. It is in France only (*see* BEET) that its manufacture has been tried, and resulted in ultimate success, so as to push the colonial sugar out of the market.

In Ireland, the manufacture was successful and remunerating, but the English Government laid on a heavy duty, in order to protect its West India sugar, and thus crushed the manufacture from beet.

In France, this growth of beet is a common branch of husbandry, and sugar is not only made on large scales by the manufacturers, but by housewives of the farm-house, as a branch of domestic economy, requiring not more skill or trouble than cheese-making or brewing.

The beet-root sugar-makers on a large scale refine their sugars, and produce sugar which, for whiteness and beauty, is unequalled by the refined sugar from West India sugar. Bulk for bulk, however, the refined West India sugar is sweeter than the refined beet-root sugar; but, weight for weight, they are equally sweet. A lump of refined beet-root sugar of the first quality is lighter than a lump of equal dimensions of refined West India sugar, probably because it is more pure and free from extraneous matter; but a pound weight of beet-root sugar differs from a pound weight of West India sugar only in our receiving more of these lumps in our pound weight. It is, for domestic use, even more economical.

From 5 to 7 *per cent.* of raw or Muscovado sugar appears to be the usual produce from a given weight of beet-roots. From a given weight of this raw sugar, 40 per cent. of the finest white refined sugar, with 15 per cent. of inferior refined sugar, are the quantities produced; making about 2 lbs. 4-5ths weight of the finest white refined sugar from every 100 lbs. of raw beet-roots. The pulp from which the juice is extracted, and the other residue of the manufacture, are used for feeding cattle. According to M. Chaptal, the value of the molasses, pulp, &c. is one-fourth of the expense of the manufacture. It is a promising feature of the manufacture, that it is linked with the ordinary business of husbandry—that it operates upon a known root cultivated for feeding cattle, and that the farmer, whether he raises beet-root for feeding cattle, or for sale to the sugar-baker, is cultivating a green crop, which, in his ordinary rotation of crops, he would at any rate raise on a part of his farm.

The beet best for sugar is white and yellow, and that which is red outside and white within. It thrives best in mixed soils. In France the juice is expressed with Burette's or Odobel's rasps for potatoes and beet. Tin-rasps with holes answer in a small way, but the above rasps are cylinders armed with saws and turned by machinery. The pulp is then put in bags, and pressed, yielding in juice 60 or 75 per cent. of the weight of the raw root. It produces crystals of sugar and bad-flavored molasses, from which, however, good rectified spirits are produced.

Another mode.—After the roots are reduced to pulp by rasps, it is placed in bags and submitted to presses which yield from 65 to 80 per cent. of juice from the pulp. This marks from 5° to 9° of Beaume.

It contains sugar in crystals and molasses; also, water, leaven, &c. It may at once be set to ferment with its own leaven, and it works well.

An hectare (2·47 acres) will yield 80,000 or 100,000 lbs. of beet-root, costing per 1000 lbs. about 5 or 6 francs; and 1000 lbs. yield 700 lbs. of juice of 9° gravity, which, diluted to 5°, yield 7½ gallons of fine spirit at 19°, or 0·941 spec. grav.

There is even more advantage from first separating the sugar, but the molasses is impregnated with much saltpetre, though it yields more spirit than the molasses of the sugar-cane, and the flavor is very pleasant. Properly treated by fermenting, 22 gallons of syrup yield 16 or 17 gallons of spirit at 19°. Some add grain to the fermenting solution. Dombasle and other distillers get 22 of spirit from 22 of the beet-root molasses.

White or yellow beet-root, or the white inside with red skins, are the best for sugar, or for distillation.

The stem and leaves of the common beet, when dried and burned, yield ashes so rich in potass, that it surpasses many of the commercial varieties.

SUGAR OF LEAD, properly *acetate of lead*, is prepared by dissolving pure litharge, with heat, in strong vinegar, made of malt, wood, or wine, till the acid be saturated. A copper-boiler, rendered negatively electrical by soldering a strap of lead within it, is the best adapted to this process on the great scale. 325 parts of finely ground and sifted oxide of lead, require 575 parts of strong acetic acid, of specific gravity 7° Beaume, for neutralization, and afford 960 parts of crystallized sugar of lead. The oxide should be gradually sprinkled into the moderately hot vinegar, with constant stirring, to prevent adhesion to the bottom; and when the proper quantity is dissolved, the solution may be weakened with some of the washings of a preceding process, to dilute the acetate, after which the whole should be heated to the boiling point, and allowed to cool slowly, in order to settle. The limpid solution is to be drawn off by a syphon, concentrated by boiling to the density of 32° B., taking care that there be always a faint excess of acid, to prevent the possibility of any basic salt being formed, which would interfere with the formation of regular crystals. Should the concentrated liquor be colored, it may be whitened by filtration through granular bone black.

Stoneware vessels, with salt glaze, answer for crystallizers. Their edges should be smeared with candle-grease, to prevent the salt creeping over them by *efflorescent vegetation*. The crystals are drained, and dried in a stove-room very slightly heated. Linen, mats, wood, and paper, imbued with sugar of lead, and strongly dried, readily take fire, and burn away like tinder. When the mother waters cease to afford good crystals, they should be decomposed by carbonate of soda, or by lime skilfully applied, when a carbonate or an oxide will be obtained, fit for treating with fresh vinegar. The supernatant acetate of soda may be employed for the extraction of pure acetic acid.

Acetate of lead is much used in calico-printing. It is poisonous, and ought to be prepared and handled with attention to this circumstance.

There are two subacetates of lead; the first of which, the ter-subacetate, has three atoms of base to one of acid, and is the substance long known by the name of Goulard's extract. It may be obtained by digesting with heat a solution of the neutral acetate, upon pure litharge or massicot. The solution affords white crystalline scales, which do not taste so sweet as sugar of lead, dissolve in not less than 30 parts of water, are insoluble in alcohol, and have a decided alkaline reaction upon test paper. Carbonic acid, transmitted through the solution, precipitates the excess of the oxide of lead in the state of a carbonate, a process long ago prescribed by Thenard for making white-lead. This subacetate consists of 88·66 of oxide, and 13·34 acid, in 100 parts. It is employed for making the orange sub-chromate of lead, as also sometimes in surgery.

SULPHATE, is a name given to a salt composed of sulphuric acid united to a metallic oxide.

SULPHATE OF ALUMINA AND POTASSA. (*See* ALUM.)

SULPHATE OF AMMONIA, is a salt sometimes formed by saturating the ammonia liquor of the gas-works with sulphuric acid; and it is employed for making carbonate of ammonia. (*See* AMMONIA and GAS COAL MANUFACTURE.)

SULPHATE OF BARYTA, is the

mineral called heavy-spar, which frequently forms the gangue or vein-stone of lead and other metallic ores.

SULPHATE OF COPPER, *Roman or blue vitriol*, is a salt composed of sulphuric acid and oxide of copper, and may be formed by boiling the concentrated acid upon the metal, in an iron pot. It is, however, a natural product of many copper mines, from which it flows out in the form of a blue water, being the result of the infiltration of water over copper pyrites, which has become oxygenated by long exposure to the air in subterranean excavations. The liquid is concentrated by heat in copper vessels, then set aside to crystallize. The salt forms in oblique four-sided tables, of a fine blue color; has a specific gravity of 2·104; an acerb, disagreeable, metallic taste; and, when swallowed, it causes violent vomiting. It becomes of a pale dirty blue, and effloresces slightly, on long exposure to the air; when moderately heated, it loses 36 per cent. of water, and falls into a white powder. It dissolves in 4 parts of water, at 60°, and in 2 of boiling water, but not in alcohol; the solution has an acid reaction upon litmus paper. When strongly ignited, the acid flies off, and the black oxide of copper remains. The constituents of crystallized sulphate of copper are—oxide, 31·80; acid, 32·14; and water, 36·06. Its chief employment in this country is in dyeing, and for preparing certain green pigments. (*See* SCHEELE'S and SCHWEINFURTH GREEN.) Farmers sprinkle a weak solution of it upon their grains and seeds before sowing them, to prevent their being attacked by birds and insects.

SULPHATE OF IRON. *Green vitriol*, copperas. Names given to the combination of sulphuric acid with protoxide of iron. It is made up—

1 Equivalent sulphuric acid	40
1 Equivalent protoxide iron	28
7 Equivalents of water	63
	131

It is generally made from the bituminous shales of or near the coal beds. The shales of the midland counties of New York afford the materials for making sulphate of iron; and in the coal regions along the slope of the Alleghanies it is found abundantly, and is found crystallized in eastern Tenessee.

Sulphate of iron is generally made from combinations of iron with brimstone, called iron pyrites, or, in common language, copperas stones, gold stones, or horse gold. These stones being collected in great quantity, are laid in heaps about two feet thick, upon a clay floor, surrounded by boards, that direct the rain-water that falls upon them, to flow into a cistern. The copperas-stones are five or six years before they yield any considerable quantity of strong liquor. In time, the stones turn to a vitriolic earth, which swells and ferments like leavened dough. When a bed is come to perfection, it is refreshed every four years, by laying fresh copperas-stones on the top. When a new bed is made, the work is hastened by mixing a good quantity of the old fermented earth with the new stones.

When the copperas-liquor is 14 pennyweights strong it is esteemed rich. It will dissolve the shell off an egg in three minutes, and produce holes in any clothes on which it may fall.

The liquor is boiled in leaden vessels, old iron is put in at first, and more added as fast as it dissolves. The boiling is esteemed finished when a little of the liquor, put into an earthen-ware dish, and cooled, deposits crystals on the sides.

In some works, iron is added to the liquor in the cistern; and, of course, less is required in the boiling. There is another kind of pyrites, which contains a double proportion of sulphur; this sort does not alter by exposure to the weather, until the extra proportion of sulphur is removed, either by roasting in piles, or by distilling in close vessels. There is also a kind of bituminous earth, that produces copperas by exposure to the air, and from which it may be obtained by washing with water in the usual manner. Copperas is also manufactured by dissolving old iron in weak sulphuric acid, at 35° Beaume, and crystallizing the solution.

Its color is a bright green, and its taste very astringent. A solution in water, dropped on oak bark, instantly produces a black spot. It is in request with dyers, tanners, and the manufacturers of ink, and, for their use, is artificially prepared from pyrites, which being moistened and exposed to the air a crust is formed upon it, to be dissolved in water, and, from this, crystals of vitriol are obtained by evaporation. Green vitriol is used in dying woollen articles, hats, &c., black, and it is the basis of ink, and used in the manufacture of Prussian blue. Reduced to powder, dried, and mixed with powder of galls, it forms the dry, portable ink-cakes and powders.

When the green sulphate is exposed

to the air it is decomposed, and gradually converted into red oxide of iron and persulphate of iron. When copperas is heated in a crucible, or over a lamp, it is converted into the red oxide or peroxide of iron.

An excellent powder for applying to razor-strops, is made by igniting together in a crucible equal parts of well-dried copperas and sea salt. The heat must be slowly raised and well regulated, otherwise the materials will boil over in a pasty state, and the product will be in a great measure lost. When well made, out of contact of air, it has the brilliant aspect of plumbago. It has a satiny feel, and is a true *fer olegiste*, similar in composition to the Elba iron ore. It requires to be ground and elutriated; after which it affords, on drying, an impalpable powder, that may be either rubbed on a strop of smooth buff leather, or mixed up with hog's-lard or tallow into a stiff cerate.

SULPHATE OF MANGANESE is prepared on the great scale for the calico-printers, by exposing the peroxide of the metal and pitcoal ground together, and made into a paste with sulphuric acid, to a heat of 400° F. On lixiviating the calcined mass, a solution of the salt is obtained, which is to be evaporated and crystallized. It forms pale amethyst-colored prisms, which have an astringent bitter taste, dissolve in 2½ parts of water, and consist of—protoxide of manganese 31·93, sulphuric acid 35·87, and water 32·20, in 100 parts.

SULPHATE OF MERCURY is a white salt which is used in making corrosive sublimate. (*See* MERCURY.) The subsulphate, called *turbith mineral*, is a pale yellow pigment, and may be prepared by washing the white sulphated peroxide with hot water, which resolves it into the soluble supersulphate, and the insoluble subsulphate, or *turbith*. It is poisonous.

SULPHATE OF ZINC, called also *white vitriol*, is commonly prepared in the Harz, by washing the calcined and effloresced sulphuret of zinc or blende, on the same principle as green and blue vitriol are obtained from the sulphurets of iron and copper. Pure sulphate of zinc may be made most readily by dissolving the metal in dilute sulphuric acid, evaporating and crystallizing the solution. It forms prismatic crystals, which have an astringent, disagreeable, metallic taste; they effloresce in a dry air, dissolve in 2·3 parts of water at 60°, and consist of—oxide of zinc, 28·29; acid, 28·18; water, 43·53. Sulphate of zinc is used for preparing drying oils for varnishes, and in the reserve or resist pastes of the calico-printer.

SULPHITES are a class of salts, consisting of sulphurous acid, combined in equivalent proportions with the oxidized basis.

SULPHUR. *Brimstone.* A yellow brittle mineral product, found in various parts of the world; but apparently most abundant in volcanic regions. It most commonly occurs massive; but it is sometimes met with crystallized in the form of an oblique rhombic octoedron. Fine specimens of this description are seen in our mineral cabinets, and bear a high price. A considerable quantity of sulphur is also obtained from some of its metallic combinations, such as the sulphurets of copper and of iron. These ores are heated, or roasted, as it is termed, in furnaces so constructed that the sulphur vapor may be condensed, and from time to time collected; this, when purified by fusion, is cast into moulds, and forms common or *roll brimstone*. Small quantities of sulphur also occur in several animal and vegetable products, and are frequently recognized by the odor of sulphuretted hydrogen which they evolve during putrefaction. Sulphur is a non-conductor of electricity, insipid, and inodorous, unless rubbed or heated, when it evolves a sulphurous smell. Its specific gravity is 1·99. It melts at about 216°; and when heated to about 250° it becomes a limpid, amber-colored liquid; if the heat be raised to about 450°, it again becomes viscid and deeper colored; at 480° up to its boiling point it acquires rather more fluidity; at about 600° it rises rapidly in vapor, and in close vessels condenses in the form of a fine yellow powder, composed of crystalline grains: in this state it is called *flowers of sulphur*. The earthy and metallic impurities which, with a portion of sulphur, remain in the subliming vessel, were formerly called *sulphur vivum*. When sulphur in its viscid state of fusion is poured into water it becomes a ductile mass, which slowly hardens, and which is often used for taking impressions of seals and medals. When sulphur is in the form of vapor it is of a dense orange color: its specific gravity in that state is about 6·6 and 100 cubic inches of it should therefore weigh about 206 grains.

There is another form of sulphur, which is sometimes called *milk of sulphur* (lac sulphuris) and which is a *hydrate of sul-*

phur; it is obtained by precipitating sulphur by muriatic acid from certain of its alkaline solutions. When sulphur which has been melted is suffered to cool slowly, its interior often exhibits prismatic crystals; and very beautiful specimens of this artificial crystallization of sulphur may be obtained by melting a few pounds of it in a crucible or ladle, and when partially cooled piercing the outer crust and inverting the vessel, so that the interior liquid part may run out; on breaking the mass when cold, the cavity will be found lined with prismatic crystals.

The results of the combustion of sulphur, its equivalent number (16), and several other details respecting its combinations and uses, are given under the heads of Sulphuretted Hydrogen, and of Sulphuric and Sulphurous Acids.

Sulphur is insoluble in water; it dissolves in boiling oil of turpentine, and is deposited often in crystals as the solution cools. It is also soluble in alcohol, if both substances be brought together in the state of vapor. It combines also with chlorine, bromine, and iodine. Its native combinations with the metals form some of the most important ores. It is from the sulphurets of lead and of copper that the commercial demands for these valuable metals are almost exclusively supplied.

Sulphur is of great importance in the arts. It is used extensively in the manufacture of gunpowder, and in the formation of sulphuric acid, or oil of vitriol.

A great portion of the sulphur employed in Europe is obtained from Sicily, to which country its extraction is so important, that, out of 2,000,000 inhabitants, about 20,000 are employed in it; and the amount received by Sicily for sulphur exported, amounts to $1,830,000 per annum.

There are no minerals, containing pure sulphur, found in the United States; at least, not in sufficient quantity to be of practical use. The chief sources from which sulphur can be obtained, are the sulphurets of the metals, which we possess in great abundance. Sulphur may be extracted from iron pyrites, by simple distillation in iron or stone, when they yield one half the sulphur they can contain; the remainder, sulphuret of iron, is easily converted into copperas. Almost the whole of the crude sulphur of this country is imported from Europe.

Sulphur exists in nature not only in the mineral, but most abundantly in the vegetable kingdom also: without it plants could not exist; for there is no plant in which albumen is not found, and to the existence of albumen, sulphur is an indispensable requisite. In the animal kingdom, too, sulphur exists in large quantities.

SULPHURATION, is the process by which woollen, silk, and cotton goods are exposed to the vapors of burning sulphur, or to sulphurous acid gas. In the article Straw-hat Manufacture, this operation has been referred to.

Sulphuring-rooms are sometimes constructed upon a great scale, in which blankets, shawls, and woollen clothes may be suspended freely upon poles or cords. The floor is flagged with a sloping pavement, to favor the drainage of the water that drops from the moistened cloth. The iron or stoneware vessels, in which the sulphur is burned, are set in the corners of the apartment. The windows and the entrance door must be made to shut hermetically close. In the lower part of the door there should be a small opening, with a sliding shutter, which may be raised or lowered by the mechanism of a cord passing over a pully.

The aperture by which the sulphurous acid and azotic gases are let off, in order to carry on the combustion, should be somewhat larger than the opening at the bottom. A lofty chimney carries the noxious gases above the building, and diffuses them over a wide space.

When the chamber is to be used, the goods are hung up, and a small fire is made in the draught-stove. The proper quantity of sulphur being next put into the shallow pans, it is kindled, the entrance door is closed, as well as its shutter, while a vent-hole near the ground is opened by drawing its cord, which passes over a pulley. After a few minutes, when the sulphur is fully kindled, that vent-hole must be almost entirely shut, by relaxing the cord; when the whole apparatus is to be let alone for a sufficient time.

The object of the preceding precautions is to prevent the sulphurous acid gas escaping. This is secured by closing the door imperfectly, so that it may admit of the passage of somewhat more air than can enter by the upper seams, and the smallest quantity of fresh air that can support the combustion.

SULPHURETTED HYDROGEN, is a gas, composed of one part of hydrogen and sixteen parts of sulphur, by weight. Its specific gravity is 1·1912, compared to air = 1·0000. It is the active constituent of the sulphurous mineral waters. When breathed, it is very deleterious to animal life; and being nearly twice as dense as air, it may be poured from its generating bottle into cavities; a scheme successfully employed by M. Thenard to destroy rats in their holes.

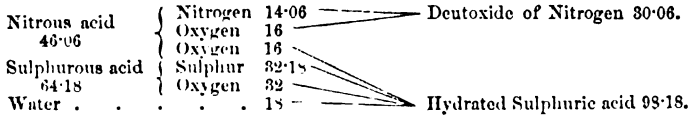
SULPHURIC ACID. The most important compound of sulphur with oxygen. It occurs native in volcanic districts in equatorial Asia, and in Italy and Sicily, and occasionally in springs, where there is organic matter brought into contact with a ferruginous sulphate: this occurs in some of the springs of western New York. When pure or anhydrous (without water) it consists of an equivalent of sulphur united with three equivalents of oxygen, but it is never known except as a hydrated acid. The manufactories where it is made require large room, and entail great expense for the purchase of platinum stills. The manufacture is but small in this country; the greater portion being derived from England, of which there are 50,000 tons annually made.

Hydrated sulphuric acid has been known since the fifteenth century. There are two distinct processes by which it is at the present time prepared, namely, by the distillation of green sulphate of iron, and by the oxidation of sulphurous acid by nitrous acid.

The first process is still carried on at Nordhausen in Saxony; the sulphate of iron, derived from the oxidation of iron pyrites, is deprived by heat of the greater part of its water of crystallization, and subjected to a high red heat in earthen retorts, to which receivers are fitted as soon as the acid begins to distil over. A part gets decomposed by the very high temperature; the remainder is driven off in vapor, which is condensed by the cold vessel. The product is a brown oily liquid, of about 1·9 specific gravity, fuming in the air, and very corrosive. It is chiefly made for the purpose of dissolving indigo.

The second method, which is perhaps, with the single exception mentioned, always followed as the more economical, depends upon the fact that when sulphurous acid, nitrous acid, and water are present in certain proportions, the sulphurous acid becomes oxidized at the expense of the nitrous acid, which by the loss of one-half of its oxygen sinks to the condition of deutoxide of nitrogen. The operation is thus conducted:—A large and very long chamber is built of sheet-lead supported by timber framing; on the outside at one extremity a small furnace or oven is constructed, having a wide tube leading into the chamber. In this sulphur is kept burning, the flame of which heats a crucible containing a mixture of nitre and oil of vitriol. A shallow stratum of water occupies the floor of the chamber, and sometimes a jet of steam is also introduced. Lastly, an exit is provided at the remote end of the chamber for the spent and useless gases. The effect of these arrangements is to cause a constant supply of sulphurous acid, atmospheric air, nitric acid vapor, and water in the state of steam, to be thrown into the chamber, there to mix and re-act upon each other. The nitric acid immediately gives up a part of its oxygen to the sulphurous acid, becoming nitrous; it does not remain in this state, however, but suffers further de-oxidation until it becomes reduced to deutoxide of nitrogen. That substance in contact with free oxygen, absorbs a portion of the latter, and once more becomes nitrous acid, which is again destined to undergo a de-oxidation by a fresh quantity of sulphurous acid. A very small portion of nitrous acid, mixed with atmospheric air and sulphurous acid, may thus in time convert an indefinite amount of the latter into sulphuric acid, by acting as a kind of carrier between the oxygen of the air and the sulphurous acid. The presence of water is essential to this re-action.

We may thus represent the change:—



Such is the simplest view that can be taken of the production of sulphuric acid in the leaden chamber, but it is too much to affirm that it is strictly true; it may be more complex. When a little water is put at the bottom of a large glass globe so as to maintain a certain degree of humidity in the air within, and sulphurous and nitrous acids are introduced by separate tubes, symptoms of chemical action become immediately evident, and after a little time, a white crystalline matter is observed to condense on the sides of the vessel. This substance appears to be a compound of sulphuric acid, hyponitrous acid, and a little water. When thrown into water, it is resolved into sulphuric acid, deutoxide of nitrogen, and nitric acid. This curious body is certainly very often produced in large quantity in the leaden chambers, but that its production is indispensable to the success of the process, and constant when the operation goes on well and the nitrous acid is not in excess, may perhaps admit of doubt.

The water at the bottom of the chamber thus becomes loaded with sulphuric acid; when a certain degree of strength has been reached, it is drawn off and concentrated by evaporation, first in leaden pans, and afterwards in stills of platinum, until it attains a density (when cold) of 1·84, or thereabouts; it is then transferred to carboys, or large glass bottles fitted in baskets, for sale. An inferior kind of acid is now made by burning iron pyrites, or poor copper ore, as a substitute for Sicilian sulphur; this is chiefly used by the makers for their own consumption; it very frequently contains arsenic.

Sulphuric acid is a limpid colorless fluid, of a spec. grav. of 1·8. It boils at 620°; it freezes at 15°. But the temperature at which the diluted acid congeals is singularly modified by the quantity of water which it contains. When of the spec. grav. of 1·78 (which may be regarded as a compound of 1 atom of dry acid and 2 of water), it freezes at 40°, and remains solid for a long time at several degrees above that point: if the density be either diminished or increased, a greater cold is required to congeal it.

It is acrid and caustic, and intensely acid in all its characters, even when largely diluted. Its attractions for bases is such that it separates or expels all other acids more or less perfectly from their combinations. Its affinity for water is such that it rapidly absorbs it from the atmosphere, and when mixed with water much heat is evolved; thus by suddenly mixing 4 parts of the acid and 1 of water at 60°, the temperature rises to 300°. Its attraction for water also causes the sudden liquefaction of snow; and if mixed with it in due proportion, an intense cold is the consequence. It acts energetically upon animal and vegetable substances, generally charring them, and often, as in the case of *sugar*, with singular rapidity.

The acid, as it usually occurs in commerce, under the name of *concentrated sulphuric acid*, is a compound of 1 atom of anhydrous acid and 1 of water. The anhydrous sulphuric acid is constituted of 16 sulphur (1 atom), and 24 oxygen (8 atoms); its equivalent, therefore, is 16+24=40: this is the composition of the acid as it exists in the *anhydrous sulphates*. The strongest liquid acid consists of 40 of the dry or anhydrous acid (1 atom), and 9 water (1 atom), and is therefore represented by the equivalent 40+9=49.

Sulphurous acid.—A compound of 1 equivalent of sulphur and 2 equivalents of oxygen: it is a gas which is poisonous, producing suffocation. It may be made by burning sulphur in a chamber with air when the acid vapors rise. It is also made by boiling sulphuric acid with charcoal or carbonaceous matter, when the sulphuric loses its oxygen and is converted into sulphurous acid.

It is found to escape in torrents from the mouths of volcanoes; and it is generally believed that its inhalation caused the death of Pliny the elder, A.D. 99. It is found that this acid is the only material with which woollens and silks can be bleached, and its application to this purpose is very simple and extensive. Sulphurous acid is soluble in water, but this solution had no application until of late years. It is now used for destroying colors. There is a substance imported into England from the Cape of Good Hope, called jute, which had hitherto been considered of no use, from the supposed impossibility of bleaching its fibre; but this has lately been effected, and a white and silky appearance imparted to it. Sulphurous acid is the only thing by which this bleaching can be effected; for if placed in an alkaline liquor, jute is reduced into a soft pulpy state.

SUMACH. The powder of the leaves, peduncles, and young branches of the *Rhus coriaria* and *Rhus cotinus*, shrubs which grow in Hungary, the Bannat, and the Illyrian provinces. Both kinds contain tannin, with a little yellow coloring matter, and are a good deal employed for tanning light-colored leathers; but the first is the best. With mordants, it dyes nearly the same colors as galls. In calico-printing, sumach affords, with a mordant of tin, a yellow color; with acetate of iron, weak or strong, a gray or black; and with sulphate of zinc, a brownish yellow. A decoction of sumach reddens litmus paper strongly; gives white flocks with the proto-muriate of tin; pale yellow flocks with alum; dark blue flocks with red sulphate of iron, with an abundant precipitate.

The R. Typhina grows in the Northern States: the bark is powdered for tanning. The *R. Glabra* grows in the Middle States. The *R. Pumila* grows in the mountains of Carolina. It is the most poisonous of the genus. The *R. Venenata* is found in the Northern and Middle States. *R. Copallina* grows in the Middle and Southern States. Several species of the celebrated Japan varnish is obtained from a species of Rhus.

SURVEYING. In practical mathematics, the art of determining the boundaries and superficial extent of a portion of the earth's surface. The object of a survey may be either to ascertain the contents of a field or portion of land, or to determine the relative distances and bearings of the most prominent objects of a country for the purpose of constructing a map, or to determine the form and dimensions of a portion of the earth's surface with a view to deduce the magnitude and figure of the earth by comparing the geodetical distances between given points with their astronomical positions. In all cases the operation is conducted on the same principles; but while the first requires only the application of the merest elements of arithmetic and trigonometry, the last can only be accomplished with the aid of instruments of the most refined description, and processes of calculation deduced from mathematics of the highest order.

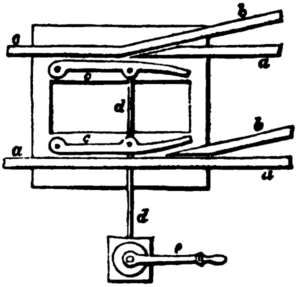
SUSPENSION BRIDGE. In architecture, a bridge in which the roadway, instead of being carried over the supporting points, is suspended from them, the supporting points being chains or other flexible materials. The principle has recently been carried to a great extent in England, as in the case of the Menai bridge; but its application is old, and has long been practised among people who have attained very little, if any, skill in the arts. (*See* BRIDGE.)

SWINE STONE. Fetid or bituminous limestone, which exhales a disagreeable odor on friction.

SWING. The ship at anchor is said to swing when she changes her position at the turn of the tide.

SWIVEL. In gunnery, a small cannon; so called from its being fixed in a *swivel*, by means of which it may be directed to any object. Swivels are chiefly used at sea, and are placed on the ship's side, stern, or bow, and also in the tops.

SWITCH. The mechanism by which parallel or diverging rails are connected.



The annexed cut at once illustrates the principle, and gives an example of a very common arrangement of switches; *a*, *a*, is the straight, and *b*, *b*, the diverging line of rails; *c*, *c*, the switches, laid upon a broad flat plate, and turning on a joint at one extremity; *d*, a rod joining the opposite ends, so as to render the motion of both simultaneous; *e*, a handle working a small eccentric acting upon the rod *d*, in such a manner as to open or close the switches *c*, *c*, and consequently guide the wheels either upon the continuous or diverging line as may be required. (*See* RAILWAY.)

SYMPIESOMETER. A kind of barometer, contrived by Mr. Adie of Edinburgh, for measuring the weight of the atmosphere by the compression of a column of gas. It consists of a glass tube about 18 inches long, having the lower end bent up like the tube of the wheel barometer, each end being terminated by an elongated bulb. The upper end is hermetically sealed, but the lower end is left open. The upper part of the tube is filled with hydrogen gas, and the lower part with some fixed oil. The pressure of the atmosphere is exerted upon the surface of the oil, which is exposed to it in the turned up open end of the tube. This pressure causes the oil to stand at a certain height in the tube, and to produce a certain compression in the column of hydrogen gas. As the atmospheric pressure becomes greater, the oil will rise, and the gas will be compressed into less space. The change in the bulk of the gas caused by a change in the atmospheric pressure is measured by a scale. The sympiesometer is a useful instrument, but inferior in accuracy to the common barometer.

SYPHON, or crane, is a bent tube with one leg larger than the other, so that its orifice may be lower; if then the air is sucked out the short leg, being in a fluid will continue to flow till the surface is below the level of the orifice; or if the syphon is filled before it is immersed at the short end, the fluid will run out at the lower end, and will be followed as before. The syphon, for many domestic purposes, is most convenient.

Syphons are used to raise water over banks.

Mr. O. P. Laird, a farmer at Oneida Castle, N. Y., has a syphon in successful operation which conveys water to his house, a distance of sixty-six rods, over a ridge of land sixteen feet high, in half inch lead-pipe, No. 1. It is discharged four feet lower than the surface of the water in the spring, and at the rate of eighteen gallons per hour.

Syphons will continue to work, provided they are perfectly tight, and if there is a moderate amount of fall from the surface of the water in the well to the place of delivery. Water is raised in a syphon on the same principle that it is in the suction pump, and may be elevated to the same hight, to wit, thirty-two feet. The objection to raising it very high in a syphon is, that air separates from water when thus raised, and the higher it is drawn the more. It is essential that there should be sufficient current to carry out this air as fast as it is evolved, otherwise it would accumulate and stop the water. Four feet of fall answers the purpose. Every thing depends on the perfect air-tightness of the pipe.

SYRINGE. In hydraulics, a machine consisting of a small cylinder with an air-tight piston or sucker, which is moved up and down in it by means of a handle. The lower end of the cylinder terminates in a small tube, through which a fluid is forced into the body of the cylinder by the atmospheric pressure when the handle is drawn up, and then expelled in a small jet by pushing the handle in the opposite direction. The syringe acts on the principle of the sucking pump. The syringe is also used as a pneumatic machine for condensing or exhausting the air in a close vessel, but for this purpose it must be furnished with two valves. In the condensing syringe, the valves open downwards and close upwards; in the exhausting syringe they are closed downwards and opened upwards. (*See* AIR GUN and AIR PUMP.)

TACAMAHAC. A resin obtained from the *Faguru octandra*, a tree which grows in Mexico and the West Indies. It occurs in yellowish pieces, of a strong smell, and a bitterish aromatic taste. That from the island of Madagascar has a greenish tint.

TACHOMETER. A contrivance invented for the purpose of indicating minute variations in the velocity of machines. When a vessel containing a fluid is whirled rapidly round a vertical axis, the centrifugal force produced by the whirling motion causes the fluid to recede from the axis, and to rise on the sides of the vessel, so that the surface of the fluid assumes a concave parabolic form; and the distance to which the centre of the surface falls below its original level is proportionate to the velocity of rotation, and subject to corresponding variations. Any method, therefore, of measuring or rendering visible the depression of the central surface will indicate the variations of velocity. The method usually adopted is the following: A glass tube open at both ends, and expanding at one extremity into a bell, is immersed with its wider end in mercury contained in a cup. The tube is so suspended as to be unconnected with the cup. This tube is then filled to a certain height, with spirits tinged with some coloring matter, to render it easily observable. The cup is attached to a spindle turned by the machine. Now as the cup is whirled round by the spindle, the level of the mercury in the bell falls, and the spirit therefore descends in the tube. As the motion is continued, every change of velocity causes a corresponding change in the level of the mercury, and consequently also in the height of the spirits in the tube; and as the capacity of the bell is much greater than that of the tube, a very small change in the level of the mercury causes a considerable change of the height of the spirits in the tube.

TAFFETA. A light silk fabric, with a considerable lustre or gloss.

TAFIA. A variety of rum.

TAGLIA. In mechanics, the name given to a particular combination of pulleys. The taglia consists of a system of fixed pulleys collected in one common block, and also of a system of movable pulleys in a separate block, to which the weight is attached, with one string going round all the pulleys, and having one of its ends fixed to a point in the system, and the other end going from one of the fixed pulleys drawn by the power. Sometimes several taglias are combined, so that one acts upon the other; the system is then a *compound taglia*. (*See* PULLEY.)

TALC. A mineral genus, which is divided into two species, the common and the indurated. The first occurs massive, disseminated in plates, imitative, or crystallized in small six-sided tables. It is splendent, pearly, or semi-metallic, translucent, flexible, but not elastic. It yields to the nail; spec. grav. 2·77. Before the blowpipe, it first whitens and then fuses into an enamel globule. It consists of—silica, 62; magnesia, 27; alumina, 1·5; oxide of iron, 3·5; water, 6. Klaproth found 2¾ per cent. of potash in it. It is found in beds of clay-slate and mica-slate, in New England. It is an ingredient in rouge for the toilette, communicating softness to the skin. It gives the flesh polish to soft alabaster figures, and is also used in porcelain paste.

The second species, or talc-slate, has a greenish-gray color; is massive, with tabular fragments, translucent on the edges, soft, with a white streak; easily cut or broken, but is not flexible; and has a greasy feel. It occurs in the same localities as the preceding. It is employed in the porcelain and crayon manufactures; as also as a crayon itself, by carpenters, tailors, and glaziers.

TALLOW. The concrete fat of quadrupeds and man. That of the ox consists of 76 parts of stearine, and 24 of oleine; that of the sheep contains somewhat more stearine. (*See* FAT and STEARINE.)

The Tallow-tree is a native of China, and belongs to the natural family *euphorbiaceæ*. At the close of the season the leaves turn bright-red, and, as the capsules fall off, leaving the pure white seeds suspended to filaments. From a remote period, this tree has furnished the Chinese with the material out of which they make their candles. The capsules and seeds are crushed together, and boiled; the fatty matter is skimmed as it rises, and condenses on cooling. The candles made of this substance are very white; and red ones are manufactured with the addition of vermilion. It is now cultivated in the vicinity of Charleston and Savannah with great promise.

TAMPING. A term used by miners to express the filling up of a hole bored in a rock for the purpose of blasting.

TANK. In gardening, a cistern or reservoir, made of stone or timber, or some other material, used in collecting and preserving water during a scarcity or drought. Tanks are sometimes built in the ground, and lined with lead or cement.

TANNER'S BARK. The bark of oak, chesnut, willow, larch, and other trees, which abounds in tannin, and is used for preparing leather. After being exhausted of the tanning principle by being chopped into small pieces, or bruised, or steeped in water, it is laid up in heaps to dry, and sold to gardeners for the purpose of producing artificial heat by fermentation in pits or beds, in bark-stoves or other out-houses, or pits. (*See* STOVE.)

TANNIC ACID. This term has been especially applied to a substance obtained by Pelouze by acting upon bruised galls by common ether; it is a white uncrystalline powder, very astringent, little soluble in water, and reddening litmus. When moistened and exposed to air it becomes converted into gallic acid. It is extremely astringent, and appears to be the active principle of tanning substances (tannin) in general. Its equivalent, deduced from the analysis of the neutral *tannates*, appears to be 426. Its ultimate elements are 30 atoms of carbon, 18 of hydrogen, and 24 of oxygen.

TANNIN. The pure astringent principle of vegetables, upon which their power of converting skin into leather depends. Its leading character is its property of producing a dense whitish precipitate in a strong solution of animal jelley, such, for instance, as isinglass. It may be obtained tolerably pure by infusing bruised grape seeds in cold water; or more circuitously by adding acetate of copper to filtered infusion of galls, washing the precipitate, and decomposing it (diffused through water) by sulphurated hydrogen. On evaporating its solution, it is obtained as a pale yellow extract, of a strong astringent taste. The action of astringents upon persalts of iron has given rise to its distinction into two varieties; the first changing them to deep blue or black, the second to green. The tan of galls, oak bark, grape seeds, &c., possesses the former property; that of catechu and tea the latter.

By digesting powdered charcoal in nitric acid, and carefully evaporating the solution so obtained, Mr. Hatchett succeeded in procuring a brown substance of an astringent taste, and precipitating solution of gelatine, which he terms, therefore, *artificial tan*.

TANNING. The formation of leather from skins.

It is founded on the fact, that the tannin principle precipitates gelatine, or animal jelly, in an insoluble state. Tannin also precipitates the sulphate of iron, lying between the hair and the skin. By strong extracts of the bark, Seguin tanned calf in 1 day, and oxhides in 7 or 8 days. 1 lb. of catechu is equal to 2½ galls, 8 sumach, 8½ oak-bark, 7½ willow-bark, and 18 elm-bark.

The outer coating of the hemlock, and various species of the oak are the principal materials generally used in the United States. The former for the great body of sole leather, the latter, for the various harness and upper leather. The trees are felled in the season when the sap is ascending, from 1st May to 1st September, though usually only from May 15th to August; and the bark is easily peeled off in sheets of any required length, but usually four feet long. It should be suffered to lie with the inner surface exposed to the sun one or two clear days, to dry up the sap on that surface, when it should be gathered into piles of a square form, in a dry place, on poles above the ground, and be protected by large pieces, laid carefully on the top of the pile. The body only is peeled in this country, except the larger branches of the oak; while in England the small limbs, and even twigs, all that will peel, are saved, and thought to be stronger than the body bark. Thirty days of dry weather will cure the bark sufficiently for use. But in a large business it is drawn to a road side, after harvest, and piled in like manner, and is suffered to remain until fall or winter, when it is drawn into the tannery, and stored in large piles in the open air or in cheap open sheds, and taken into the tannery as wanted. At the North this is usually done in winter, which makes good sleighing, almost as important to the tanner as bright skies in June and July. Chemical tests give to hemlock bark only 3½ to 6 per cent. tannin. American oak not more than half as much, while English hedgerows is 16 per cent. Various other foreign substances contain tannin. Valonia, of Turkey, or the acorn cup and ball, gathered in a green state, is the favorite in England, and it is believed that the great burr oak of the Middle States yield an annual crop of the same material, which if gathered would be sufficient for all the tanning of America, and save the destruction of our noble forests now going on at the North so rapidly. The strongest article known is kutch, imported from the East Indies, evidently an extract boiled down to salts, which contain about 55 per cent. pure tan. It is too expensive for common use in this country, but is much used in England, in liquors for heavy stock. It is computed that for every cord of hemlock bark four trees are peeled, and one cord will tan five hides. If the whole quantity of leather is 1,000,000 sides, 200,000 trees are annually destroyed to furnish the bark.

The skins of animals are immersed, for several days, or even weeks, in water with bark, mostly of oak or larch; and other astringent substances, as terra japonica, are employed, which shortens the time, but renders the substance more hard and brittle. Another method is by *tawing*. They are left to soak, for six weeks, in water, with fresh slaked lime, changed twice, rinsed, again soaked in water mixed with wheat bran, until they float, but, when beaten down, do not rise again. The bran is then scraped off, and a liquid paste is prepared, for 100 sheep-skins, 8 lbs. of alum and 8 lbs. of salt are dissolved, in warm water, and added to 20 lbs. of fine wheat flour and 96 yolks of eggs. A ladle full of this paste is put into a trough of warm water, in which 12 skins remain for some time, and are then pulled and stretched; and this is repeated twice. They are then left six days, and afterwards quickly dried.

Slow tanning makes leather softer and stronger.

Time and labor are both materially reduced, and the quantity and weight of the leather increased, by the substitution of *water power* for manual labor, in many of the most laborious parts of the process; viz. to soften and cleanse the hide preparatory to the bark being applied to it; to grind the bark; to move pumps for transferring the decoction of the bark from one vat to another (much of which is necessary to be done daily in an extensive tannery), and to roll the leather preparatory to its being sent to market; also the least possible quantity of lime is now used to facilitate getting off the hair. This has been found greatly to add to the weight and quality of the leather. The application of heat to bark, in *leaches*, is found to be very important, and more particularly the application of the decoction (usually termed *liquor*) to the hide, rather than the bark.

Tanning by Bilberry or Whortleberry.

8½ lbs. of this tan dress 1 lb. of leather, while 6 lbs. are required from the oak, and tanners also gain four months.

After tanning, the currying takes place. This consists in removing all excrescences, soaking and trampling, covering with oil, and pummelling, to produce pliancy. They are then colored, white with white-lead, black with a solution of iron, and a second of soot, vinegar, and gum.

TANTALITE, or COLUMBITE. The ferruginous oxide of columbium. It occurs in small masses, and in octahedral crystals. It has been found in Finland and in this country.

TAPESTRY. Is an ornamental figured textile fabric of worsted or silk, for lining the walls of apartments; of which the most famous is that of the Gobelins Royal Manufactory, near Paris.

TAPIOCA. A modification of starch, partially converted into gum, by heating and stirring cassava upon iron plates. (*See* CASSAVA and STARCH.)

TAR. The viscid, brown-black, resino-oleaginous compound, obtained by distilling wood in close vessels, or in ovens of a peculiar construction. (*See* CHARCOAL, PITCOAL, and PYROLIGNEOUS ACID.) According to Reichenbach, tar contains the peculiar proximate principles, *paraffine*, *eupion*, *creosote*, *picamar*, *pittacal*, besides pyrogenous resin, or *pyretine*, pyrogenous oil, or *pyroleine*, and vinegar. The resin, oil, and vinegar are called empyreumatic, in common language.

TARTAR, called also argal or argol, is the crude bitartrate of potassa, which exists in the juice of the grape, and is deposited from wines in their fermenting casks, being precipitated in proportion as the alcohol is formed, in consequence of its insolubility in that liquid. There are two sorts of argal known in commerce, the white, and the red; the former, which is of a pale-pinkish color, is the crust let fall by white wines; the latter is a dark-red, from red wines.

TARTARIC ACID. The acid of tartar. This acid is contained in grape juice, and in tamarinds and several other fruits. It is usually obtained from purified tartar: 4 parts of powdered tartar and 1 of chalk are mixed in hot water, and the white powder which subsides (tartrate of lime) is decomposed by dilute sulphuric acid, which combines with the lime to form sulphate of lime, and the tartaric acid being liberated is obtained by evaporation. When pure it forms white crystals, composed of one equivalent of dry acid, and one of water (66+9 =75). The anhydrous tartaric acid, as it exists in the dry tartrates (tartrate of lead, for instance), is composed of

	Atoms.	Equiv.	
Carbon............	4	24	36·36
Hydrogen..........	2	2	3·03
Oxygen............	5	40	60·61
	1	66	100·00

TAWING. The art of preparing certain kinds of leather by imbuing the skins with saline, oily, and other matters. (*See* TANNING.)

TEA. The leaves of the *Thea officinalis*. This plant resembles the Camellia, but its leaves and flowers are much smaller. It is five or six feet high, and is an evergreen. It is a native of China and Japan, and has been cultivated there for centuries; was unknown in Europe till the middle of the seventeenth century, yet is now become of so much importance as to employ 50,000 tons of shipping in its transportation from Canton. It is cultivated in all parts of China, even at Pekin, which has the same latitude as Philadelphia. The plants require little care till the third year, when they are fit for gathering. In seven years the plants attain the height of six feet. The leaves are plucked off one by one with many precautions, and from six to sixteen pounds per day are plucked. The first leaves are gathered at the end of the winter, when the leaves are young and tender; the second gathering is in the beginning of spring, when the leaves are of nearly their full size; the last gathering takes place in midsummer. These are of inferior quality. There are two varieties of tea—the *Thea viridis* and *Thea bohea*. Formerly it was believed that all the green tea was gathered from *T. viridis*, but this is now known not to be so, there being a green tea district where the leaves are gathered from both varieties of trees indiscriminately. The names given in commerce are unknown to the Chinese. When the leaves are gathered they are dried in houses containing small furnaces, having an iron pan on the top of each. The leaves are rolled on tables covered with mats, and then a few pounds are laid on the iron pan heated; the workman shifts them with his bare hands lest they should burn. When he cannot bear the heat longer he transfers the tea to the mats; they are then rolled again on the pan till they are twisted: it is repeated frequently before the tea is stored, so that no moisture may remain in it. The different kinds of black and green differ not only in soil and climate but in after treatment. The color of green tea is due to an admixture of gypsum and Prussian blue, which is dusted over it in the pans.

The leaves of tea have little or no smell, and they derive their fragrance by mixing the leaves of *Olea fragrans* and *Camellia sesanqua*, also of *Polegala thezans*, and of *Rhamnus thezans*.

China tea does not turn black by water, impregnated with sulphuretted hydrogen gas; nor give a blue tinge to spirit of hartshorn. The infusion, amber colored, is not reddened by sulphuric acid. The leaves, separate or mixed, of speedwell, wild germander, black currants, mock orange, purple-spiked willow herb, sweet-briar, cherry-tree, hawthorn, bramble, sloe, are substituted for tea by dealers. Foreigners use a variety of plants, instead of Chinese tea, and *Zenopomathea Sinensis* is cultivated in France as a substitute. *Japanese camellia* leaves are frequently, by the Chinese, mixed with those of tea.

Russian tea, is leaves of saxifrage, winter green, white virgin's bower, bird cherry, drop worts, common elm, male fern, and dog-rose.

The active principle of tea is believed to be *Theine*, a substance found also in coffee and in the *ilex paraguyaensis*, a native of Brazil.

Mr. Stenhouse prepares theine by precipitating a decoction of tea with solution of acetate of lead, evaporating the filtered liquor to a dry extract, and exposing this extract to a subliming heat in a shallow iron pan, whose mouth is covered flatly with porous paper luted round the edges, as a filter to the vapor, and surmounted with a cap of compact paper, as a receiver to the crystals. In this way he obtained, at a maximum, only 1·37 from 100·00 of tea. But M. Peligot, from the quantity of azote amounting to about 6 per cent., which he found in the tea leaves, being led to believe that much more theine existed in them than had hitherto been obtained, adopted the following improved process of extraction. To the hot infusion of tea, subacetate of lead and then ammonia were added; through the filtered liquor a current of sulphuretted hydrogen was passed to throw down all the lead, and the clear liquid being evaporated at a gentle heat afforded, on cooling, an abundant crop of crystals. By re-evaporation of the mother liquor, more crystals were procured, amounting altogether to from 5 to 6 out of 100 of tea.

The composition of theine may be represented by the chemical formula, C^8, H^5, N^2, O^2; whence it appears to contain no less than 29 per cent. of nitrogen or azote.

Peligot found, on an average, in 100 parts of—

	Parts soluble in boiling Water.
Dried black teas	43·2
——— Green teas	47·1
Black teas, as sold	38·4
Green teas, ditto	43·4

Tea, by Mulder's general analysis, has a very complex constitution; 100 parts contain—

	Green.	Black.
Essential oil (to which the flavor is due)	0·79	0·60
Chlorophyle (half-green matter).	2·22	1·34
Wax	0·28	
Resin	2·22	3·64
Gum	8·56	7·28
Tannin	17·80	12·88
Theine	0·43	0·46
Extractive matter	22·80	19·88
Do. dark colored ..	—	1·48
Coloring matter separable by muriatic acid	23.60	19.12
Albumine	3·00	2·80
Vegetable fibre	17·08	28·32
Ashes	5·56	5·24

By the enterprise of Dr. Junius Smith, the cultivation of the tea-plant in the United States has been introduced, it having recently been grown in South Carolina, under circumstances which would indicate that the question of its success may soon be decided. Partial attempts have before been made by planting a few seed. But Dr. Smith has brought out plants of seven years growth. In a letter respecting this fact, he says, that on the 15th and 16th of December, 1848, he planted out at Greenville, South Carolina, the tea seed which he carried with him, and went to work preparing the ground for the reception of his tea plants, which he adds, "was no slight labor in this hilly, rocky, stumpy, rooty domain." His packages of plants arrived some time after him, and on opening them, he says several of the plants were in full bloom, with their leaves fresh and green, as if growing in China; others with the blossom bud just showing its ivory breast ready to develope all its beauties.

"You may say, therefore, that the tea plant is in blossom in South Carolina. On Tuesday, the 26th of December, he planted out the *first tea shrubs ever cultivated in the United States for agricultural and commercial purposes*. Out of five hundred plants he found five which he thought of doubtful vitality, and these he transferred to the infirmary, and subjected them to vigilant nursing."

There is a large tract of our country which falls within the latitude in which tea is most successfully raised in China. In Dr. Smith's pamphlet on the subject, he says it grows there most luxuriantly between the parallels of 20° and 45° north latitude. "In the geographical and physiological views of that portion of the United States, presumed to be best adapted to the growth of the tea plant," he says: "We may assume the latitude of 40° as the northern, and the Gulf of Mexico as the southern limits of the tea growth." That the tea plant can grow in our country is now a settled fact; but the high price of labor will retard its introduction into market, until machinery here can compete with the enormously low price of labor in China.

TEAK is one of the largest trees known, and interesting from the properties of the wood. It is considered superior to all others for ship-building, and is extensively used in the East in houses and temples. It is now planted, with a view to timber, in Bengal. The leaves furnish a purple dye, employed on cottons and silks.

TEASEL. The teasel (dipsacus fullonum) throws up its heads in July and August; these are cut from the plant by hand with a peculiarly formed knife, and then fastened to poles for drying. When dry, they are picked and sorted into bundles.

The use of heads of teasel is to draw out the ends of the wool from the manufactured cloth, so as to bring a regular pile or nap upon the surface, free from twistings and knottings, and to comb off the coarse and loose parts of the wool. The head of the true teasel is composed of incorporated flowers, each separated by a long, rigid, chaffy substance, the terminating point of which is furnished with a fine hook. Several of these heads are fixed in a frame, and with this the surface of the cloth is brushed, until all the ends are drawn out, the loose parts combed off, and the cloth ceases to yield impediments to the free passage of the wheel or frame of teasels. Should the hook of the chaff, when in use, become fixed in a knot, or find sufficient resistance, it breaks, without injuring or contending with the cloth; and care is taken, by successive applications, to draw the impediment out. The dressing of a piece of cloth consumes from 1,500 to 2,000 heads. They are used repeatedly in the different stages of the process; but a piece of fine cloth generally breaks this number before it is finished. There is a consumption answering to the proposed fineness—pieces of the best kinds requiring 150 or 200 runnings up.

They are now being gradually superseded everywhere by machinery.

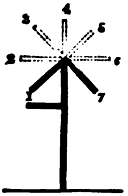
TECTORIUM OPUS. In architecture, the plasterers' work used on ceilings and interior walls: it was a composition of lime and sand, and differed from stucco, which was called albarium opus. Great pains were taken to prevent its cracking, by crossing layers of reed upon it coated with argillaceous earth previous to coating it with paint.

TELEGRAPH. The name given to a mechanical contrivance for the rapid communication of intelligence by signals. Of late years, the term *semaphore* has been introduced by the French, and frequently adopted by English writers.

Although the art of conveying intelligence by signals was practised in the earliest ages, and is known even to the rudest savages; and although its importance is not only obvious, but continually felt wherever civilization is established, it has been allowed to remain in its original state of imperfection down almost to our times. The first description of a telegraph universally applicable was given by Dr. Hooke. The method which he proposed, for it was not carried into practice, consisted in preparing as many different shaped figures, formed of deal—for example, squares, triangles, circles, &c., as there are letters in the alphabet, and exhibiting them successively, in the required order, from behind a screen.

The first telegraph actually used was the invention of Chappe. It consisted of a beam which turned on a pivot in the top of an upright post, having a movable arm at each of its extremities; and each different position in which the beam and its two arms could be placed at angles of 45° afforded a separate signal, which might represent a letter of the alphabet, or have any other signification that might be agreed upon. In 1803, the French erected *semaphores* along their whole line of coast, formed of an upright post, carrying two, or sometimes three beams of wood, each turning on its own pivot, one above the other. In 1807, Captain (now General) Pasley published his *Polygrammatic Telegraph*, which was adopted in that year by the Admiralty instead of the shutter telegraph, and has continued in use ever since.

For day signals, the telegraph consists of an upright post of sufficient height, with two arms movable on the same pivot on the top of it, and a short arm, called the *indicator*, on one side; as in the annexed figure. Each arm can exhibit the seven positions, 1, 2, 3, 4, 5, 6, 7, besides the position called the *stop*, which points vertically downwards, and is hid by the post. In order to show the number of signals that may be made with this machine, we may suppose the arm nearest the indicator, reckoning in the order of the numbers as shown in the figure, to indicate tens, and the other units; then the signal represented in the figure will be 17, which may be taken to denote a letter of the alphabet. If the arm on the left had the position indicated by 3, and that on the right the position indicated by 6, the signal would be 36. In this manner, the number of separate and independent signals, with their signification, will be as in the following table:—



No. of Signal.	Signification.	No. of Signal.	Signification.	No. of Signal.	Signification.
1	A	15	L	36	V
2	B	16	M	37	W
3	C	17	N	45	X
4	D	23	O	46	Y
5	E	24	P	47	Z
6	F	25	Q	56	
7	G	26	R	57	
12	H	27	S	67	
13	I	34	T		
14	K	35	U		

In 1803, Ronalds constructed a telegraph by galvanism, which worked through coils of 8 miles of wire, and Wedgewood, in 1817, formed and worked a voltaic telegraph.

TELEGRAPHS, ELECTRIC. It is mainly owing to the labors of S. F. B. Morse, in the United States, and Cook and Wheatston in England, that electrical telegraphs owe their practical application.

In Cook and Wheatston's first apparatus, five needles were arranged, with their axis in a horizontal line, the needles hanging vertically: each of the electro-magnetic coils was connected with one of the long conducting wires at one end, and was united at the other with a common rod of metal, which joined together similar ends of all the coils. The current was transmitted from opposite ends of the wires, where an appropriate set of finger keys (5 pair) for making connection with the battery, was placed through two of the wires at once. When the key was pressed down, the needles assumed various positions with respect to each other, and these were made to indicate signals according to entries in the signal book. The instruments at the two stations are always reciprocating; that is, at the ends of the line was placed an instrument, a set of finger keys, and a voltaic battery, so that either station could receive or transmit a signal. By a beautiful arrangement, a bell or alarm could be rung, when the attention of the clerk at the distant terminus was required. Mr. Cook obtained, in 1838, further improvements on this apparatus without altering its chief features.

The basis of this, and indeed of all electric telegraphs, is the fact discovered by Œrsted, that when a magnetic needle is subjected to a current of electricity, the needle deviates towards a right angle to the position in which it stood originally. This was the simplest form of telegraph of Cook and Wheatston:—A magnetic needle was placed behind a vertical dial, its axis is prolonged out in front of the plate, and a second needle suspended to it, so that the latter moves similarly when the needle behind is impelled; a coil of wire traverses above and below the inner needle, and when the ends of this coil are brought into contact with the poles of a battery, and the needle thus brought within the circuit, it is immediately deflected, and carries the outer needle along with it. This latter is the indicator. Stops are placed on each side of the needle to limit its motion on either side, and the letters are read off by a scale of arbitrary movements. Thus if the point of the needle move once to the right to express *A*, twice to the right might express B; once to the left, E, and so on.

Dr. Stenheil constructed an electric telegraph between Munich and Bogenhausen, in 1837, in which he availed himself of the conducting power of the earth, thus saving the cost of erection, the earth occupying the place of the return wire.

In the same year Mr. Morse's invention was publicly tested. It was the first practical registering instrument, the various signals being traced on a strip of paper. In June, 1844, the telegraph was constructed by him between Baltimore and Washington, through the aid afforded him by Congress, who advanced 30,000 dollars. Mr. Morse has taken out patents for improvements in his apparatus, the latest of which was in 1848, for an "electro-magnetic recording telegraph." To Mr. Morse is certainly due the credit of being the first who set up a practical magnetic telegraph invented in 1832.

Morse's Telegraph. This, the oldest telegraph of this kind in the United States, may be described as worked by a main circuit and distant battery.

The principle of this telegraph is based upon the temporary induction of a piece of soft iron with magnetism, by the current of galvanism passing around it; this piece of soft iron is called an electro-magnet, and it operates a walking-beam pen, to make mechanical marks upon a ribbon of paper carried along with a uniform motion, against the face of a grooved metal roller.

The batteries used are Grove's zinc and platinum, and two liquids. Any number of these may be used; from 4 to 10 at termini are the usual number. To form the electric circuit, one end of a copper wire is attached to the end platina plate, and the other end of the copper wire to the zinc cylinder. A wire is not required to run round all the circuit—any metallic connection, such as brass plates, &c., &c., may form part of it. The battery with the key attached, and the small table, we will suppose to be at the Philadelphia station, and the telegraph register to be at New-York. A wire runs from the platina plate up to the metallic binding screw connection on the small table above, and the other wire runs from the zinc, and is connected with the first wire by the metallic connection of the register at New-York. This forms the circuit. The key is fixed upon a pivot axis, to be gently pressed by the operator's fingers on the top of an ivory button. The circuit is now broken, and a small gap in the key above the wire from the battery shows the metallic connection to be open. By pressing upon the butt end of the key, its metal surface comes in contact with the metal termination of the wire from the battery, and then the circuit is closed, and the electric fluid fleets along to the distant station, as in the present instance, New-York.

In connection with the register there is a ribbon of paper passing from the roll between two small metal rollers of the register. This strip is drawn through between the rollers by their motion, they revolving towards the paper roll, drawing in the paper. Motion is given to these rollers by a train of clockwork gear wheels, which are moved by the weight below the machine. The upper small roll has a small groove running around its periphery, and the ribbon of paper is drawn through against its under surface. The instrument to indent the paper is a pen-lever. It is suspended on a pivot axis at its middle, and its action is like a walking-beam, but the stroke it makes is very short—not over the one-eighth of an inch at both ends. This pen-lever is very nicely poised, and at its extreme end from the paper its stroke is nicely regulated by a set or button screw. There is a metal pen attached to the lever and fixed on a pivot like a walking-beam. When one end is drawn down, the other end flies up, and having a steel point on it it marks a strip of paper running along a roller, which is drawn along between other two rollers. Now, by letting the other end of this pen come up, the steel point drops, and then it is thrown up again, leaving a space between the two marks on the paper. Now, as the paper is always moving, and as the point is held to it for a longer or shorter time, marks are made of dots, spaces and dashes—thus . for E, and — for L, and . — . for F, and thus by a combination of dots, spaces and dashes, the whole alphabet is formed, and these letters made into words, and the words into sentences —compose the message. An electro-magnet is used on Morse's telegraph to operate the walking-beam pen. It is fitted with an armature, whose attraction and withdrawal gives motion to the lever or walking-beam; the breaking and closing the circuit is effected by a key of brass insulated by ivory at Philadelphia, and writes the messages in New-York.

The magnet in connection with the register, is made of a piece of soft iron, pure and free from carbon, sulphur, &c., and is wrapped round with fine copper wire, covered with silk. This coil of wire is called a *helix*. It is attached to the wire of the battery by a metallic connection at one end, and the other end of the helix —for it must be made of continuous wire —is attached to the wire from the other end of the battery, thus forming part of the electric circuit. This magnet is made almost always of a U form, but this is not so essential. This electro-magnet has no attractive force except when the electric circuit is closed and the fluid rushing along the wire, and then its attraction is considerable. The end of the pen lever has the steel pen on it, so that when the operator at Philadelphia presses his hand upon the key, the circuit is closed, the end of the pen-lever above the magnet is drawn down to the magnet, and the pointer at the other end is thrown against the strip of paper. Whenever the finger is lifted off the key, the circuit is open, the magnet loses all attractive power, and the pointer then drops and does not touch the paper. It will thus be observed that, by tapping on the key at Philadelphia the circuit is broken and closed to New-York, and the electro-magnet actuates the pen-lever to produce the characters we have described, which are put together to make words, and the words then put together to make sentences.

There is a key and register placed on the same table at every station; and this is necessary for the reception and transmission of messages. Each station has a battery and each register has a *registering magnet*, which produces the marking and is in the *local circuit*. But there is another magnet called the *receiving magnet* placed in the circuit of the *main line;* it also forms a part of the apparatus of the register. The office of the receiving magnet is to close and break the circuit of the register magnet. It is on the exclusive use of this instrument and the combination, that the value of the Morse patent is based. At the distance of 30 miles the electro fluid becomes so attenuated in power that it would not be capable of indenting the paper. To render the attenuated current available, the receiving magnet is interposed, differing from common electro-magnets in the length and fineness of the helix, 3000 feet of wire, well covered, being no uncommon length; the lever attached to the armature of this magnet is so delicate as to affect the surface if coated with a little dust, or even strongly breathed on. The immediate use of it is to break and close the circuit, consisting of the register magnet, small battery, and sufficient connecting wire.

Grove's battery, though objectionable on account of the nitric acid vapors, is still the most economical. The zinc cylinders of the battery are 2 lb. weight each, and cast very smooth. Sulphate of soda is added to the sulphuric acid in the zinc cell; this prevents local action and renders reamalgamation unnecessary.

The number of the cells give efficiency to the battery. Eighteen members of Smee's battery, each of an inch square, are competent to work through 80 miles; a single cell, no larger than a thimble, will work through six miles. A series of 30 of Grove's battery is the average number for 150 miles. The "main battery" does not require to be charged oftener than once in 5 weeks. The acids of the "local battery" require daily replenishment. The use of poles for the support of wires is universal in this country. In Prussia, the wires are buried under ground and covered with gutta percha. In England they are generally encased in a tube and lie upon the ground or but little buried: latterly they are being placed on poles similar to the practice of France and this country. The height of the poles set in these states vary, being on an average 30 feet, buried 5 feet in earth, and the diameter at the top being not less than 6 inches; on these are placed glass caps or rests for the wire, which is of iron, weighing from 300 to 330 lbs. per mile. It is either single or twisted, naked or galvanized. The naked wire is generally preferred, and costs from 6 to 10 cents a lb.

The great simplicity of this American telegraph is the use of the ground as the return conductor: thus rendering only one wire needful. It also proves a better conductor than wire, the current seeming to prefer it. Communication is easily established with it: in cities a gas pipe answers; any where a metal plate, buried in the ground, or immersed in a river, effects the object. A hair wire suspended from the travelling wire and dipping in a river is sufficient to break the circuit as effectually as if the wires were cut. No matter how many stations intervene between the termini, there is no alteration produced on the current when the wires are well insulated. On one of the lines there are 16 stations, each of which unite with each, or all the others, each receiver preserving a closed circuit, while the transmitting operator manipulates with his key. The average price of transmission is 25 cents for ten words 100 miles; this is much below the Prussian tariff. In England the charge is so high as to leave its benefit only in the hands of a few. A skilful operator knows by the sound of the call in his office where the intelligence comes from, and the abbreviations are so numerous that a ready penman cannot keep up with the delivery of a message: as many as 25,000 letters have been transmitted in an hour and a half by two instruments and wire. Changes of weather in the earth's surface, and general disturbance of atmospheric electrical equilibrium renders the insulation imperfect and transmission of messages are put a stop to.

The country between Mobile and New-Orleans is an instance of the difficulty of writing through a damp atmosphere, for although it is only 190 miles by telegraph line, yet it is with difficulty they can write that distance, and it requires the most strict attention to the line to keep it in working order, while on the same line they work in many places over 400 miles.

House's Telegraph machinery is much more complex than Morse's, and costs in construction ten times as much. Its object is to make at one end of a wire the revolution of a disc, upon whose edge the Roman letters are raised synchronous with the operations of a lettered finger board at the other end of the wire. So that at the touching of A on the finger board, the wheel presents and impresses *A* on a slip of paper. The paper is moved, so that the letters succeed each other, as in ordinary printing, and a visible impression is made by the arrangement similar to the manifold writer. The operator at New-York plays upon his machine, like a lady at her piano, and at Boston a little arm is seen revolving round and round, clicking and printing, in black letters, R, O, Y, A, L, E, H, O, U, S, E, on a strip of paper. On Morse's telegraph the messages have to be re-written by a penman into plain English.

Bain's telegraph.—Bain, in 1843, took out the patent for his copying telegraph.

The machine consists of a drum, on which is rolled a card, which, with a weight attached, moves a train of wheels. In connection with the drum, by pinion and axle and bent wheel, hangs a rod, on which is placed a revolving pendulum supported by a flexible cord with a screw attached, which can raise or lower the pendulum; to another wheel, the axle of which is carried through the print plate of the instrument two lesser wheels are attached, upon which there are metal cylinders movable by a pulley and axle, which winds a silk cord fastened to a steel rod to the extremity of which is a binding screw to hold a fine wire or needle. This latter can be brought into contact with the cylinders, any non-conducting substance interposed between the cylinders and the needle interrupts the current, and the apparatus thus becomes available for copying work. The motion given to the wheelwork by the weight is rendered uniform by the revolving pendulum. A peculiarity in the form of the escapement gives it an isochronous motion by means of a vertical pendulum, the length of which is regulated by screws, so as to check any deviation in rate of motion of the revolving pendulum. Electro-magnets are thus dispensed with. This apparatus is used for transmitting and receiving; for transmission, the message may be written on tinfoil or paper, coated with Dutch metal, varnish, or any non-conductor, or by moistening the back of the paper and then writing on the metal surface with a blunt style. This communication is then laid on one of the cylinders, and a cylinder of the corresponding instrument at the receiving station is covered with chemically prepared paper. A current of electricity being generated by a battery at the transmitting station, is passed through the instrument there and conveyed by a single wire to the corresponding instruments at the receiving station, whence it returns back through the earth to the battery. As the cylinders rotate, the arm descending with the needle traces a continuous spiral line from the top to the bottom of the cylinder which becomes a permanent mark on the chemically prepared paper, broken at intervals, corresponding to the marks made with the non-conducting material on the metallized paper.

The writing may be made with a conducting material on a non-conducting surface, when the marks composing the received communication will be represented by dots and lines upon a plain ground.

The chemical paper consists of fine thin paper soaked with a solution of yellow prussiate of potash, and afterwards dipped in weak nitric acid. This tends to facilitate the decomposition of the prussiate, the acid being a good conductor; a blue mark is left where the needle touches.

Mr. Bain's telegraphs have been exhibited before the French government, and will form the medium of telegraphing in that republic. On that occasion, a committee of the French Legislative Assembly, at the head of which was the celebrated astronomer, Le Verrier, was appointed to investigate the merits of this invention. They caused the experiments to be repeated in their presence. A message consisting of several thousand words was transmitted to Lille and back along a single wire (the wire being united at Lille so as to carry back the message), at the rate of about 1,500 letters, or nearly 400 telegraphic words per minute. The committee reported favorably of the project, and the government ordered a set of apparatus to be constructed, to be placed in the first instance on the line between Paris and Calais. This line was completed in the early part of last year (1850), and their performance was witnessed by the correspondent of a London journal. His own dispatch was transmitted and written by the apparatus in his presence at the rate of 1,000 letters per minute, probably as quick as messages will be transmitted by it. The characters were perfectly distinct, and the dispatch was read from them also in his presence. This speed is not always attained. Bain's telegraph is not worked in this country any quicker than Morse's. In both cases the rapidity depends on the skill of the operator.

Bain's telegraph not only prints, but makes marks of a chemical nature, in character nearly like that of the Morse telegraph, but no "electro-magnet" is used except to rectify operators. By breaking and closing the circuit at New-York, the pen which is in contact with chemically prepared paper at Philadelphia, makes blue marks on the paper, and these blue marks make the message. There is one part of this invention which is a curiosity in its way. The operator writes the message first on a strip of paper, by perforating it with small holes, for the dashes and the dots, and by making this, in a very ingenious manner, break and close the circuit, a message may be transmitted to any place. When there is time to prepare messages, this is a ready way to transmit them rapidly. This invention embraces the idea of printing a pattern of calico in Philadelphia by breaking and closing the circuit in New-York.

O'Reilly's Telegraph. This is not strictly a distinct telegraph, but a line of telegraphic communication established by Mr. O'Reilly, in which he avails himself of the Morse line over most of the distances, as from New-York to Louisville: thence to New-Orleans, Bain's telegraph is used now, it having replaced Messrs. Zook and Barns' apparatus, a form which has not been patented, but which had been in operation on that line. The O'Reilly lines extend, besides the two distances mentioned, from Pittsburg to Cleveland and Detroit: from Dayton, O., by Lake Erie to Chicago: from the Ohio River to Evansville, connecting the previous line at Terre Haute: and from St. Louis to Dubuque, Iowa, supplying the intermediate cities. The New-Orleans route divides into two branches, one of which proceeds by Tuscumbia, Alabama, to Memphis; the other proceeds from Jackson, Miss., to Vicksburg, making a total distance in the southern route of 1,100 miles. On this line also, the naked iron wire is used, it being found to act as a better insulator than the galvanized wire, for, in the latter instance, when the wire is touched by leaves of trees, which is unavoidable in many places, the current is conveyed off the polished metal, but if the wire be rusted, it becomes insulated by that means, and the current suffers less interruption.

The following was the extent of telegraph communication in this country, Nov. 1847:—

	Miles.
New-York to Buffalo	509
Troy to Saratoga	36
Auburn to Elmira	84
Ithaca to Binghampton	46
Syracuse to Oswego	38
Buffalo to Chippewa, C. W.	12
Queenstown to Toronto	150
Hamilton to London	75
Toronto to Montreal	376
Montreal to Quebec	180
New-York to Washington, D.C.	224
Washington to Petersburg	175
*Philadelphia to Pittsburg	296
Philadelphia to Pottsville	106
*Lancaster to York	25
Pittsburg to Cincinnati	120
Massillon to Cleveland	136
Cincinnati to Louisville, Ky.	85
New-York to Boston	237
Boston to Lowell, Mass.	26
*Boston to Portland, Maine	74
Total	2989

Contemplated then, since perfected.

Petersburg to New Orleans	1427
Buffallo to Detroit	350
Detroit to Milwaukie	350
Bridgeport to Montreal	300
Norwich to Worcester	85
Louisville to St. Louis	300
	2812

From Macon to Flanepec	1000
St. Louis to New-Orleans	1000
	2000

The line is double nearly the whole way, one wire connecting each intermediate place, and one connecting the extreme points. These lines to which asterisks are appended are also used by the O'Reilly line.

The foregoing are on the Morse principle, which, with a few minor lines, bring up the whole extent of the Morse lines to nearly 12,000 miles, and there are about 2,000 on House and Bain's principles. The telegraph now extends from Halifax to New-Orleans, and as far west as Dubuque, Iowa, making an extent of 22,000 miles.

A contract has been entered into by the Mexican Government with Wm. George Stewart, Esq., the Mexican consul at New-York, and Senor Juan de la Granja, of Mexico, to build a line from Vera Cruz to the city of Mexico—a distance of three hundred miles—on the understanding that it will be in operation by the first of May, 1852, as far as El Ojo de Agua, a distance of one hundred and twenty miles from the latter place. Another line will soon after be built between Acapulco and the city of Mexico. When both are completed there will be magnetic communication between the Atlantic and the Pacific.

Mr. Wm. Robinson, of this country, is about to erect and manage, in Sweden and Norway, a number of lines of magnetic telegraph. He has been granted the privilege for the enterprise, which is to endure for fifty years; and a company, including several heavy capitalists in this city (N. Y.) and Stockholm, has been formed under his auspices.

Messrs. Westbrook and Rogers, of this country, have invented a telegraph which records signs on a metallic surface connected with the earth by a wire conductor at one end, and to a galvanic battery and the earth at the other end of the circuit, by the use of acidulated water or other fluid. The patentees claim "recording telegraphic signs on the surface of a revolving metallic cylinder plate, or other equivalent surface, by means of an acidulated or saline solution, or water held between the point of the wire conductor and the metallic recording surface, by means of a non-conducting porous substance contained in a glass or other non-condensing reservoir in which the recording fluid is contained, to which the electric current from the battery is applied by means of any of the known forms of manipulators and anvils used for making and breaking the circuit. The recording fluid being employed to the metallic recording surface substantially in the manner herein fully set forth, by which the use of every description of paper is dispensed with, thereby saving great expense in telegraphing."

Bakewell's electric copying telegraph is very similar to Bain's. Messrs Barlow and Foster have made improvements in insulating and transmitting the currents. The limits of this work do not admit of entering upon these more fully.

On the 27th August, 1850, an experiment was commenced at Dover, England, for establishing a telegraph between it and Calais, in France. The steamer Goliath took the wires and machinery on board. The wire, to the extent of 30 miles, and covered with gutta-percha, was wound on a drum revolving between the paddle-wheels. Cape Grinez, on the French coast, was fixed as the point nearest Dover, being 21 miles distant. The wires being made fast on the English side, and the vessel steaming five miles per hour, the wire as it unwound passed over the stern of the steamer into the water, and was sunk to the bottom by weights of 25 lbs. each. The wires were carried on the French side up the declivity of the cape 124 feet. It was carried up to Shakspear's Cliff, on the Dover side. On the next day, the batteries being affixed, the line worked with complete success; the greatest depth of water was 180 feet. This fact has shown that there is no difficulty in telegraphing through the ocean if the wires be not deranged.

It has been proposed to extend telegraph wires across the Atlantic, between Halifax or Boston and the west coast of Ireland. It is difficult to understand, however, how these could be sunk to the bottom of the ocean, which is between 2 and 3 miles deep in some places, and if not sunk the floating wires are liable to damage from icebergs or fish.

TELESCOPE. An optical instrument for viewing distant objects. This subject belongs more properly to the department of science, but as it is an instrument in such general use a short notice will be given here. It is not the mere distance which renders an object invisible or even indistinctly seen. There are other causes which come into play, such as the diminution of the angle which the object subtends which diminishes as the distance increases: again, the light which renders the object visible, becomes less dense as the distance increases, but in a much faster proportion, and all the rays of light which have an object do not reach the observer, some being lost in the air in their passage. For an object to be seen in ordinary daylight it must subtend at the eye an angle of 30″. The least angle under which contiguous objects may be clearly distinguished is one minute: by the aid of the telescope an enlarged image of the object is obtained, and within certain limits the object is not only apparently enlarged but rendered brighter to the eye. The telescope, then, enlarges the angle under which objects are seen. Its invention has been ascribed to various persons. Brewster believes that either Roger Bacon or Baptista Porta formed it for experiment. It has also been ascribed to Metius, Lippersey, and Jansen. Lippersey in 1608 actually made one, but Jansen's instrument being more notorious roused the attention of Galileo, in 1609, who set about considering the means whereby distant objects might be rendered visible. He was soon in possession of a telescope which magnified three times: subsequently he increased its power very much, and at the close of that year he discovered the satellites of Jupiter.

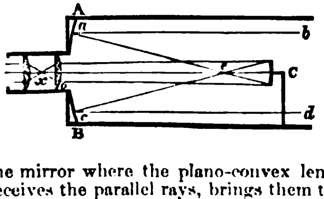
There are two kinds of telescopes, *refracting* and *reflecting* telescopes. The former depending on the use of appropriately figured lenses, through which the rays of light are passed, and the latter on the use of specula or polished metal mirrors which reflect the rays; an inverted image of the object being formed in both cases in the focus of the lens or mirror. These are a later invention than refracting telescopes, which were of a simple character at first, made up chiefly of a lens, forming the object-glass, and an eye-glass also of one lens, but of a much shorter focus. The different refrangibility of the luminous rays produced a series of prismatic colors, which tinged the images formed by the telescope and rendered their outline thereby indistinct.

Under the article LENS has been mentioned the various forms of these surfaces, to which reference may be had for illustration in describing this instrument. By combining these in a tube, or case, the parallel rays from the object are brought to one point without loss or interference. The naked eye can see objects distinctly when placed at a great distance, that is, when the rays proceeding from the object are parallel or nearly so; consequently if an object be placed very near the eye, and if the rays which flow from it can be made to enter the eye nearly parallel to each other, we must see it distinctly. This parallelism may be effected by placing close to the eye a convex lens and holding the object in its focus. If the latter be called F, and the centre of the lens C, by placing the object a little nearer than F the rays which flow from it may receive the exact degree of divergency which they have when the object is placed six inches from the eye, the nearest distance at which we can see minute objects distinctly. If the distance C F be one inch, the object at F will have its apparent magnitude six times greater than when it is seen at the distance of six inches without the lens. It is therefore said to be magnified six times by the lens. This constitutes the single *microscope*, and the magnifying power of such may be always found by dividing six inches by the focal distance of the lens. Thus, a lens the 1-10th of an inch in focal length will magnify 60 times, and one the 1-1000th of an inch 600 times.

To the instrument with one lens which thus magnifies where the naked eye is six inches behind it, additional magnifying power may be given by bringing the eye within an inch of the image, that is, by viewing the image with an additional lens when the focal distance is an inch. This lens will magnify the image six times, and if that image had been magnified by the former lens ten times, then the magnifying effect of the two lenses will be $10 \times 6 = 60$ times. Such is the *astronomical* telescope by which objects are seen inverted, and the magnifying power of which is always equal to the focal length of the *object-glass*, or the lens next the object, divided by the focal length of the *eye-glass* or the lens next the eye.

The principle of the telescope is then simply this: the object-glass forms in its focus a distinct image or picture of the object which, though very much smaller than the object, is yet seen under a much greater angle, or magnified, and this image so magnified is seen under a still greater angle, or still farther magnified, by the eye-glass, which enables the eye to see it distinctly at a distance less than six inches. The *terrestrial* telescope differs from the astronomical in having two additional lenses placed in the tube of the eye-glass, for the purpose of restoring the inverted image to its erect position and thereby accommodating the telescope to terrestrial objects; the focal lengths of these additional lenses being usually the same as that of the eye-glass. The performance of these refracting telescopes depends most essentially on the goodness of the object-glass, for if the first image be bright and distinct and perfectly *achromatic*, or without the prismatic colors at its edge, there is little difficulty in forming eye-pieces to magnify it without causing it to undergo any sensible alteration. When suitable lenses are obtained, it is only necessary to adjust them at proper distances in the tube to complete the modern telescope: the tube keeping off the external rays which would otherwise cross and interfere with the parallel rays coming from the object. In *reflecting* telescopes a speculum or mirror performs the same office which the object-glass does in those of the refracting kind: it is therefore called the object-mirror. This telescope is constructed in various forms, differing from each other chiefly in reference to the contrivances which have been adopted for bringing the focal image into a convenient situation for being viewed by the eye-piece. The chief forms are the Newtonian, Gregorian, Cassegranian and Herschelian. In the Newtonian telescope the mirror was at the bottom of the tube and the image received on a small diagonal plane speculum, which threw the rays to the side of the tube and formed the image there, when it could be viewed by the eye-piece.

In the Gregorian telescope the inconvenience of taking a lateral view is avoided. It consists in a concave speculum A, B, fixed in a tube, but pierced in the centre with a hole, through which, by means of a lens or a combination of lenses, the image of the object is viewed. The rays forming the image of the object, are incident on a small concave mirror C, previous to which the rays have crossed themselves at the focus *e*, the image therefore at C is an inverted one: this image is viewed through the aperture in the mirror where the plano-convex lens receives the parallel rays, brings them to a focus at *x*, at the farther side of which is placed the eye-glass or lens which receives the rays diverging from *x*, restores them to their parellelism and brings the image back again to an upright condition. The observer, in using this telescope, is placed in a line with the object; whilst in Newton's he is at right angles to it. The curvature of the smaller mirror is usually spherical, though it should properly be elliptical. The larger mirror is generally hyperbolic. In the Cassegranian telescope a convex mirror is substituted for the concave one.



Mr. Nasmyth has produced an improvement in the reflecting telescope, which consists in having the contrings or trunions at the centre of gravity, through one of which in a tubular form the rays from the reflector within are thrown into the eyes thus placed, as in the Newtonian telescope, at the side: and the advantage of this arrangement is that the eye does not require to move on a movement of the telescope. In order that the telescope may be accommodated to objects at different distances, it is necessary that the tube should be made to slide backward and forward, and the object will always be inverted from the intersection of the rays by refraction, and its use will be thus limited. An erect image may always be obtained by adding two other convex lenses behind C, in the illustration, and of the same focal length: but a loss of light is necessarily produced by their use. Spherical aberration may be prevented in telescopes in the same way in which it is prevented in microscopes, namely, by giving to the reflecting surface such a configuration as will enable it to reflect all the rays incident upon it to one focus. The parabola and ellipse possess this property, and nothing but the mechanical difficulty of constructing mirrors of these figures prevents their being employed instead of spherical mirrors. If a concave eye-glass be substituted for the lens C in the simple refracting telescope, we have the Galilean telescope, which exhibits objects in an erect position and with very great clearness.

TELL-TALE. The dial plate at the wheel, showing the position of the tiller.

TELLURIUM. This rare metal has only been found in small quantities in the gold mines of Transylvania: it occurs in the metallic state, combined with gold or silver. It is white, brilliant, brittle, and easily fusible. Its specific gravity is about 6·25. It is combustible, and often exhales a peculiar odor, like horse-radish, which Berzelius ascribes to the presence of minute portions of selenium. It forms a protoxide and a peroxide, often called *tellurous* and *telluric acids*. Its equivalent is either 32 or 64. Tellurium forms a gaseous compound with hydrogen, which has been called *hydrotelluric acid*.

TENACITY OF THE METALS. The power which metallic wires possess of sustaining, without breaking, the action of a suspended weight. *See* Cohesion, Strength of Materials.

TENON. In architecture, the end of a piece of wood or timber, diminished usually by one third of its thickness, which is received into a hole corresponding to it in size, called a mortise, by which expedient the two are held jointed or fastened together.

TERRA JAPONICA. The old pharmaceutical designation of the substance now called *catechu*. It was formerly regarded as an earthy mineral.

TERRA SIENNA. A brown ocherous clay brought from Sienna, and sometimes used as a pigment.

TERRACE. In architecture, a raised natural or artificial bank for the purpose of affording a promenade.

TERRA COTTA, literally baked clay, is the name given to statues, architectural decorations, figures, vases, &c., modelled or cast in a paste made of pipe or potter's clay and a fine-grained colorless sand (fine quartz), with pulverized potsherds, slowly dried in the air, and afterwards fired to a stony hardness in a proper kiln.

TERRE-VERTE. Green earth. A species of chlorite of a green or olive color, found in Germany, France, Italy, and this Continent. According to Klaproth, it is a hydrated silicate of oxide of iron and potash, with a little magnesia and alumina. The green earth of Verona, once used as a pigment, is a sub-species of this mineral.

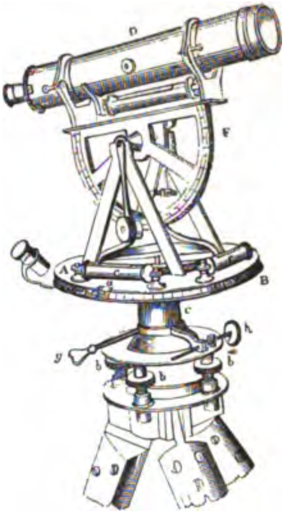
TESSELATED PAVEMENT. In ancient architecture, a pavement formed of small square pieces of stone called *tesseræ* or *dies*. They are frequently, indeed mostly, found inlaid in different colors and patterns, and with a central subject. They are imbedded in cement, and rest on prepared hard strata.

TEST. In chemistry, any thing by which we distinguish the chemical nature of substances from each other; thus, infusion of galls is a *test* of the presence of iron, which it renders evident by the production of a black color in water and other liquids containing that metal; in the same way sulphuretted hydrogen is a test of the presence of lead, and nitrate of baryta of sulphuric acid. In metallurgy and assaying, the porous crucible which absorbs the liquid vitrifiable oxide of lead and other metals combined with it is sometimes called the *test*.

TEXTILE FABRICS. Under the articles of FLAX, COTTON, and LINEN, the manufacture of those fabrics is described. Under the present title, only a few additional observations are required: the reader finding further information under the head WEAVING.

The first business of the weaver is to adapt those parts of his loom which move the warp, to the formation of the various kinds of ornamental figures which the cloth is intended to exhibit. This subject is called the *draught*, drawing or reading in, and the cording of looms. In every species of weaving, whether direct or cross, the whole difference of pattern or effect is produced, either by the succession in which the threads of warp are introduced into the heddles, or by the succession in which those heddles are moved in the working. The heddles being stretched between two shafts of wood, all the heddles connected by the same shafts are called a leaf; and as the operation of introducing the warp into any number of leaves is called drawing a warp, the plan of succession is called the draught. When this operation has been performed correctly, the next part of the weaver's business is to connect the different leaves with the levers or treddles by which they are to be moved, so that one or more may be raised or sunk by every treddle successively, as may be required to produce the peculiar pattern. These connections being made by coupling the different parts of the apparatus by cords, this operation is called the cording. In order to direct the operator in this part of his business, especially if previously unacquainted with the particular pattern upon which he is employed, plans are drawn upon paper. These plans are horizontal sections of a loom, the heddles being represented by lines across the paper, and the treddles under them, and crossing them at right angles. In actual weaving, the treddles are placed at right angles to the heddles, the sinking cords descending perpendicularly as nearly as possible to the centre of the latter. Placing them at the left hand, therefore, is only for ready inspection and for practical convenience. The right hand thread passes through the eye of a heddle upon the back leaf and is disconnected with all the other leaves; the next thread passes through a heddle on the second leaf; the third, through the third leaf; the fourth, through the fourth leaf; and the fifth, through the fifth or front leaf. One set of the draught being now completed, the weaver recommences with the back leaf, and proceeds in the same succession again to the front. Two sets of the draught, similar to the one which had been furnished, it is understood by weavers (who seldom draw more than one set), must be repeated until the warp is concluded. When they proceed to apply the cords, the right hand part of the plan serves as a guide. In all the plans furnished to the weavers, excepting one, which shall be noticed, a connection must be formed, by cording, between every leaf of heddles and every treddle; for all the leaves must either rise or sink. The raising motion is effected by coupling the leaf to one end of its correspondent top lever; the other end of this lever is tied to the long march below, and this to the treddle. The sinking connection is carried directly from under the leaf to the treddle. To direct a weaver which of these connections is to be formed with each treddle, a black spot is placed when a leaf is to be raised, where the leaf and treddle intersect each other upon the plan, and the sinking connections are left blank. Those who have been accustomed to manufacture and weave ornamented cloths, never consume time by representing either heddles or treddles as solid or distinct bodies. They content themselves with ruling a number of lines across a piece of paper, sufficient to make the intervals between these lines represent the number of leaves required. Upon these intervals they merely mark the succession of the draught, without producing every line to resemble a thread of warp. At the left hand they draw as many lines across the former as will afford an interval for each treddle; and in the squares produced by the intersections of these lines, they place the dots, spots, or ciphers which denote the raising cords. It is also common to continue the cross lines which denote the treddle a considerable length beyond the intersections, and to mark by dots, placed diagonally in the intervals, the order or succession in which the treddles are to be pressed down in weaving.

THEODOLITE. A most important surveying instrument for measuring horizontal angles, or the angular distances between objects projected on the plane of the horizon. This instrument is variously constructed, and provided with subordinate apparatus, according to the price, or the particular purposes to which it is to be applied. One of the most generally useful, consists of two concentric horizontal circular plates A and B, which turn freely on each other. The lower or graduated plate B, contains the divisions of the circle, and the upper or vernier plate has two vernier divisions *a*, diametrically opposite, only one of which is shown in the cut. The vertical axis C consists of two conical parts, the one working within the other. The external part is attached to the graduated plate B, and the internal to the vernier plate A. The plane of the circle is adjusted to the horizon by the screws *b b b*, acting against a plate of metal resting on the staff-head supporting the instrument. The vernier plate carries two spirit levels, *c c* at right angles to each other, with their proper adjusting screws, by which the circle is brought accurately into the horizontal plane indicated by the levels. The horizontal axis of the vertical limb of the instrument is supported by a frame attached to the vernier plate, and turning along with it about the vertical axis. To the horizontal axis D, a telescope, with cross wires in its focus, is attached, which moves in the vertical plane, by the graduated circle E, and is used for observing the objects whose angular distance is to be measured, and also for taking altitudes, or measuring vertical angles; a spirit level is fixed beneath the telescope for its adjustment. F is a microscope for reading off the vernier divisions. The screws *g*, *h*, are for regulating and fixing the external part of the vertical axis C. To measure the angular distance between any two objects, the telescope is turned round along with the vernier circle (the graduated circle remaining fixed), until it is brought to bear exactly upon one of the objects; it is then turned



round until it is brought to bear on the other object, and the arc which the vernier has described on the graduated circle, measures the angle required. The observation may be repeated any number of times in order to insure accuracy, by means of a repeating stand, which turns round concentrically with the vertical axis of the theodolite. The theodolite is not only a most essential instrument in trigonometrical surveying for determining stations, and running base-lines, but also in geodetical operations, for assisting in determining the length of an arc of the meridian. For this latter purpose it requires to be constructed on a large scale.

THERMOMETER. An instrument for measuring variations of heat or temperature.

The principle upon which thermometers are constructed, is the change of volume which takes place in bodies when their temperature undergoes an alteration. Generally speaking, all bodies expand when heated, and contract when cooled, and in such a manner that, under the same circumstances of temperature, they return to the same dimensions; so that the change of volume becomes the exponent of the temperature which produces it. But as it is necessary not merely that expansion and contraction take place, but that they be capable of being conveniently observed and measured, only a small number of bodies are adapted for thermometrical purposes. Solid bodies, for example, undergo so small a change of volume with moderate variations of temperature, that they are in general only used for measuring very high temperatures, as the heat of furnaces, of melting metals, &c. Instruments for such purposes are called pyrometers. (*See* PYROMETER.) The gaseous fluids, on the other hand, are extremely susceptible of the impressions of heat and cold; and as their changes of volume are great even with moderate accessions of heat, they are only adapted for indicating very minute variations, or for forming *differential* thermometers. (*See* DIFFERENTIAL THERMOMETER.) Liquids hold an intermediate place; and by reason of their moderate but sensible expansion through the ranges of temperature, within which observations have to be made for by far the greater number of purposes, are commonly used for the construction of thermometers. Various liquids have been proposed, as oils, ether, spirits of wine, and mercury; but scarcely any other than the two last are now ever used, and mercury by far the most generally.

The ordinary mercurial thermometer consists of a glass tube, with a bulb blown at the lower end. Some mercury is boiled in the tube, and the whole of the atmospheric air driven away by immersing the open end of the tube in a cup of quicksilver; it rises in the glass as the latter cools. It is again heated, and closed at the open end. It is then immersed in melting ice and in boiling water. The heights at which the quicksilver stands in these cases respectively, are marked 32° and 212°. The intervening space is divided into 180°, to make a Fahrenheit thermometer, and 100° to make a centigrade thermometer. Alcohol thermometers are used to indicate degrees of cold, as that liquid cannot be broken.

The *differential thermometer* consists of two legs connected, with a fluid working between them as either is made hotter than the other. It has a scale, but is not very accurate.

Thermometers are often slow in exhibiting the heat of new situations, and time should always be allowed, according to circumstances, for the progression of the atomic motion into or out of the mercury in the bulb.

The degrees of Celsius, or the centigrade scale, when desired, may be found by adding or subtracting for every degree 1·8 degree to or from the degree of Fahrenheit, and those of Reaumur, by adding or subtracting 2·25 degrees to or from Fahrenheit.

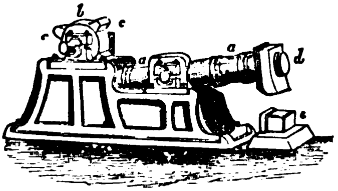
THERMOSTAT, is the name of an apparatus for regulating temperature, in vaporization, distillation, heating baths or hot-houses, and ventilating apartments, &c.; for which Dr. Ure obtained a patent in the year 1831. It operates upon the physical principle, that when two thin metallic bars of different expansibilities are riveted or soldered facewise together, any change of temperature in them will cause a sensible movement of flexure in the compound bar, to one side or other; which movement may be made to operate, by the intervention of levers, &c., in any desired degree, upon valves, stop-cocks, stove-registers, air-ventilators, &c.; so as to regulate the temperature of the media in which the said compound bars are placed. Two long rulers, one of steel and one of hard hammered brass, riveted together, answer very well; the object being not simply to *indicate*, but to *control* or *modify* temperature.

THRASHING MACHINE. The employment of thrashing machines relieves the laborers from the severest drudgery incident to agriculture; they enable the work to be done at the time there is a demand for corn; and, by doing it better, or separating the grain (particularly of wheat) more completely from the straw, they add both to the wealth of the farmer and the produce of the country. To the farmer of this continent they are invaluable, as saving the price of manual labor. This latter is, indeed, a most important consideration. It is calculated, by the best informed agriculturists, that 5 per cent., or one-twentieth part, more produce is afforded by a crop thrashed by machinery than by the old method. The modern thrashing machine was invented in Scotland, about the year 1758, by a farmer in the parish of Dumblaine, Perthshire, and afterwards brought to nearly its present state of perfection by Mr. Meikle, a millwright of Haddingtonshire, about the year 1786. Meikle's thrashing machine consists of a cylinder furnished with beaters fixed on its circumference, to which the corn being presented by rollers, the ears are beat in pieces; and while the grain drops through a grating into a winnowing machine, the straw is carried forward, and delivered by itself ready to be made up into bundles. Some thrashing machines only beat out the corn, and separate it from the straw; while others beat it out, winnow it, and sift it.

These machines may be driven by horse, cattle, wind, water, or steam. The latter is almost the only power now used.

THIEVES' VINEGAR, is a solution of camphor and essential oils in vinegar, and is used as a preventive to contagion.

TILT-HAMMER. A heavy hammer used in iron-works, which is worked by machinery, impelled either by a water-wheel or a steam-engine. Such hammers are extensively used in the manufacture of iron and steel. The hammer used for hammering the *blooms* of iron, is usually called a *lift* or *helve* hammer, and is sometimes of the enormous weight of six tons. The tilt-hammer, properly so called, is of lighter dimensions, and is worked with greater rapidity; a specimen of the kind usually employed in the manufacture of steel, and in the forging of anchors, axles, &c., is represented in the accompanying engraving. *a*, is the shank or helve, usually formed of timber, and sometimes of wrought iron; it is hung upon an axis at about one-third of its length, and is worked by a series of revolving cams or tappets *c c*, fixed into the circumference of the *cam-ring b*, mounted upon the shaft of a steam-engine or water-wheel. These cams act successively by depressing the shorter limb of the shank *a*, until, by the continued revolution, it is disengaged, and the opposite extremity, armed with a heavy cast-iron hammer *d*, descends with considerable force upon the anvil *e*. Thus a repetition of blows is kept up as long as may be required.



TIN, is rather a scarce metal, found in few parts of the world in any quantity. Cornwall is its most productive source; it also occurs in the mountains between Gallicia and Portugal, and in those between Saxony and Bohemia, and in California. Tin has also been brought from the peninsula of Malacca in India, Borneo, and from Chili and Mexico. There are only two ores of tin, the native peroxide, and the double sulphuret of tin and copper: the latter, sometimes called *bell-metal ore*, is extremely rare; and it is exclusively from the former that the commercial demands are supplied. In Cornwall, the native peroxide, or *tin stone* (which is usually blended with oxides of iron and manganese), occurs in *veins*, and in loose grains and nodules in alluvial soil; the latter is called *stream tin*, and from it the purest metal is obtained. The ore is reduced by a very simple process; it is ground, washed, and roasted in a reverberatory furnace; it is then mixed with charcoal or coke of coal and limestone, and strongly heated, so as to bring the whole into fusion, which is kept up for eight or ten hours: the lime combines with the earthy matters of the ore into a fusible slag, while the coal reduces the oxide to a metallic state, and the fused metal is drawn out at the bottom of the furnace into a clay mould. In this impure state it is exposed to a heat just sufficient to melt the pure tin, which runs off into a kettle, while the less fusible impurities remain behind: in the kettle, the tin is kept in fusion, and agitated by plunging pieces of wet charcoal into it, which causes a quantity of dross to rise to the surface, where it is skimmed off, and the purified metal is then cast into blocks of about 3 cwt. each.

The stream tin is smelted by charcoal; and the mass of grain tin obtained by such reduction is heated and let fall from a height, by which it splits into masses of a columnar fracture, which characterizes the pure metal.

Pure tin is a white, brilliant metal. It has a slight taste and smell when rubbed, and its hardness is intermediate between that of gold and lead. Its specific gravity is 7·2. It is very malleable; and one of its most useful forms is that of foil, which is made by beating: it is about a thousandth of an inch in thickness. Its ductility and tenacity are inferior to most of the other malleable metals. A tin wire 78 thousandths of an inch in diameter will not support more than 38 pounds without breaking. It produces a peculiar crackling noise when beat. Exposed to air, it soon becomes superficially oxidized; and when melted, successive films of a gray powder form upon its surface. The temperature at which it melts is about 442°. At a white heat it takes fire, and burns with a bright flame. The equivalent of tin is 58. It forms two oxides. The protoxide is thrown down by alkaline carbonates from an aqueous solution of protochloride of tin; and when dried and heated out of the contact of air, its water is expelled, and it remains in the form of a dark substance, of the specific gravity 6·6. It burns like tinder, and becomes converted into the peroxide. It is soluble in sulphuric and hydrochloric, and in dilute nitric acid, and in the pure fixed alkalies. Its salts have a strong attraction for oxygen, and easily pass into persalts; so that it is a powerful deoxidizing agent, and is often used as such in some of the chemical arts. When a solution of protochloride of tin is dropped into a solution of perchloride of gold, a purple precipitate, called, from its inventor, *purple of Cassius*, is thrown down: it appears to be a compound of peroxide of tin with protoxide of gold, and its formation depends upon the deoxidizing power of the solution of tin. When tin foil is put into nitric acid, there is violent action, attended by the decomposition of the acid and the peroxidizement of the tin, which is thus converted into a white powder: this, when edulcorated and dried at a red heat, acquires a yellow tint. It does not easily form permanent compounds with the acids; but it unites with the pure alkalies, and forms soluble compounds, which have sometimes been called *stannates*, and the peroxide itself *stannic acid*. The two oxides of tin are respectively composed of 58 tin and 8 oxygen, and 58 tin and 16 oxygen: their equivalents, therefore, are 66 and 74. Tin and chlorine also combine in two proportions: the *protochloride of tin* is formed by passing hydrochloric acid gas over metallic tin gently heated in a glass tube, or by heating a mixture of equal weights of tin filings and calomel, when it remains, after driving off the mercury, in the form of a gray solid, fusible at a red heat, and volatile at higher temperatures. Its aqueous solution is commonly termed *protomuriate of tin*. When tin foil is heated in excess of gaseous chlorine, or when 1 part of tin filings is mixed with 3 of corrosive sublimate and heated, a volatile liquid distils over, which is *perchloride of tin*, and its aqueous solution forms the *permuriate*. Exposed to air, it is decomposed by the aqueous vapor of the atmosphere, and exhales dense white fumes: hence called, after its discoverer, *fuming liquor of Libavius*. Both the protomuriate and permuriate of tin are used by dyers and calico-printers. The former is prepared by heating granulated tin in strong hydrochloric acid, as long as hydrogen continues to be evolved; the latter, by gradually dissolving granulated tin in a mixture of two parts by measure of hydrochloric acid, one of nitric acid, and one of water. These chlorides of tin are respectively composed of 58 tin and 36 chlorine, and 58 tin and 72 chlorine, and are therefore represented by the equivalents 94 and 130.

When melted tin and sulphur are brought together, a black *protosulphuret of tin* is formed. The *bisulphuret of tin* is a yellow glistening substance, sometimes called *Mosaic gold* (*aurum musivum*), and used in ornamental japanwork. It is prepared by heating in a glass retort 2 parts of peroxide of tin, 2 of sulphur, and 1 of sal ammoniac, and maintaining a low red heat till sulphurous acid ceases to be evolved. The sulphuret and bisulphuret of tin are constituted of 58 tin and 16 sulphur, and 58 tin and 32 sulphur; and have, therefore, the equivalents 74 and 80.

TINCAL, crude borax.

TIN-FOIL. (*See* TIN.)

TIN-PLATE. The only alloy of iron interesting to the arts is that with tin, in the formation of *tin-plate* or *white-iron*.

The sheet iron intended for this manufacture is refined with charcoal instead of coke, subsequently rolled to various degrees of thinness, and cut into rectangles of different sizes, by means of a shearing-machine driven by a water-wheel, which will turn out 100 boxes a day, or four times the number cut by hand-labor. The first step towards tinning is to free the metallic surface from every particle of oxide or impurity, for any such would inevitably prevent the iron from alloying with the tin. The plates are next bent separately by hand into a saddle or Λ shape, and ranged in a reverberatory oven, so that the flame may play freely among them, and heat them to redness. They are then plunged into a bath, composed of four pounds of muriatic acid, diluted with three gallons of water, for a few minutes, taken out and drained on the floor, and once more exposed to ignition in a furnace, whereby they are *scaled*, that is to say, cast their scales. An ordinary bath will suffice for scaling 1800 plates. When taken out, they are beaten level and smooth on a cast-iron block, after which they appear mottled blue and white, if the *scaling* has been thoroughly done. They are next passed through *chilled* rolls or cast-iron cylinders, rendered very hard by being cast in thick iron moulds. After this process of *cold rolling*, the plates are immersed, for ten or twelve hours, in an acidulous ley, made by fermenting bran-water, taking care to set them separately on edge, and to turn them at least once, so that each may receive a due share of the operation. From this ley-steep they are transferred into a leaden trough, divided by partitions, and charged with dilute sulphuric acid. Each compartment is called a *hole* by the workmen, and is calculated to receive about 225 plates, the number afterwards packed up together in a *box*. In this liquid they are agitated about an hour, till they become perfectly bright, and free from such black spots as might stain their surface at the time of immersion. This process, called pickling, is both delicate and disagreeable, requiring a good workman, at high wages. The temperature of the last two steeps should be at least 90° or 100° F., which is kept up by stoves in the apartments. The plates are finally scoured with hemp and sand in a body of water, and then put aside for use in a vessel of pure water, under which they remain bright and free from rust for many months, a very remarkable circumstance.

The *tinning* follows these preparatory steps. A range of rectangular cast-iron pots is set over a fire-flue in an apartment called the *stow*, the workmen stationing themselves opposite to the narrow ends. The first rectangle in the range is the tin-pot; the second is the wash-pot, with a partition in it; the third is the grease-pot; the fourth is the pan, grated at bottom; the fifth is the list-pot, and is greatly narrower than any of the rest: they are all of the same length.

The prepared plates, dried by rubbing bran upon them, are first immersed one by one in a pot filled with melted tallow alone, and are left there for nearly an hour. They are thence removed, with the adhering grease, into the first pot, filled with a melted mixture of block and grain tin, covered with about four inches of tallow, slightly carbonized. This pot is heated by a fire, playing under its bottom and round its sides, till the metal becomes so hot as nearly to inflame the grease. Here about 340 plates are exposed, upright, to the action of the tin for an hour and a half, or more, according to their thickness. They are next lifted out, and placed upon an iron grating, to let the superfluous metal drain off; but this is more completely removed in the next process, called *washing*.

The plates are then dipped in the pot containing the melted metal. They are then lifted out with tongs, rubbed with a brush, re-dipped in the tin, and then immersed in the grease-pot. It is dipped a third time, and the rim of tin removed from the under edge of the plate by dipping the edge in melted metal, when the superfluous metal becomes detached. They are finally rubbed with bran to free them from tallow, and then packed up in boxes.

Crystallized tin-plate, (see MOIREE METALLIQUE.)

TITANIUM. A rare metal, discovered by Gregor in a mineral from Cornwall called *menachanite*. Its characters were first ascertained by Klaproth, who gave it the above name. In the year 1822, Dr. Wollaston ascertained that the minute copper-colored crystals, occasionally found in the slag of the iron-smelting furnaces at Merthyr and elsewhere, were pure titanium; and it is to him that we are indebted for a precise account of its properties. In this state it has a copper color is extremely infusible, and of a specific gravity of 5·8; it is so hard as to scratch not only glass, but crystal. It resists the action of air and acids, but is oxidized by the action of nitre at a red heat. Titanium appears susceptible of two degrees of oxidizement. The protoxide of titanium is blue or purple, and appears to constitute the mineral called *anatase*. The peroxide, or *titanic acid*, exists nearly pure in *titanite* or *rutilite*, and is combined with the oxides of iron and manganese in *menachanite*.

TOBACCO. The dried leaves of the *Nicotiana tabacum*, a plant indigenous to this continent, but which succeeds very well, and is extensively cultivated, in most parts of the Old World. The recent leaves possess very little odor or taste; but when dried, their odor is strong, narcotic, and somewhat fœtid; their taste bitter, and extremely acrid. When well cured, they are of a yellowish green color. When distilled, they yield an essential oil, on which their virtue depends, and which is said to be a virulent poison. The leaves are used in various ways, being chewed, smoked, and ground, and manufactured into snuff. It is in the last-mentioned form that tobacco is principally used in Great Britain, and, though the contrary has often been asserted, its use does not seem to have been productive of any perceptible bad consequence.

The term *tobacco* is probably derived from Tabaco, a province of Yucatan, where it was first found by the Spaniards. To Sir Francis Drake and Sir Walter Raleigh has been ascribed the honor of having introduced it into England, nearly three centuries ago.

For some years past it is believed, so far as can be ascertained, there has been a comparative falling off of the tobacco crop of the country. The reason of this is to be found probably in the fact of the exhaustion of the lands devoted to this product in the largest tobacco growing regions of the Atlantic States; especially of Maryland, Virginia, and South Carolina, while there has not been, as in the case of the cotton crop, sufficient additional lands in the other parts of the country brought into cultivation to supply the deficiency. It is capable of being raised in every state in the Union; and a large breadth of land is laid out for it so far north as New York. When the plants are green, they are dried for keeping.

The plants are hung up to dry during four or five weeks; taken down out of the sheds in damp weather, for in dry they would be apt to crumble into pieces; stratified in heaps, covered up, and left to sweat for a week or two according to their quality and the state of the season; during which time they must be examined frequently, opened up, and turned over, lest they become too hot, take fire, or run into putrefactive fermentation. This process needs to be conducted by skilful and attentive operatives. An experienced man can form a sufficiently accurate judgment of the temperature, by thrusting his hand down into the heap.

According to the recent analysis of Possett and Reimann, 10,000 parts of tobacco-leaves contain—6 of the peculiar chemical principle *nicotine*; 1, of *nicotianine*; 287 of slightly bitter extractive; 174 of gum, mixed with a little malic acid; 26·7 of a green resin; 26 of vegetable albumen; 104·8 of a substance analagous to gluten; 51 of malic acid; 12 of malate of ammonia; 4·8 of sulphate of potassa; 6·3 of chloride of potassium; 9·5 of potassa, which had been combined with malic and nitric acids; 16·6 of phosphate of lime; 24·2 of lime, which had been combined with malic acid; 8·8 of silica; 496·9 of fibrous or ligneous matter; traces of starch; and 88·28 of water.

Nicotine is a transparent colorless liquid, of an alkaline nature. It may be distilled in a retort plunged into a bath heated to 290 Fahrenheit. It has a prickling, burning taste, which is very durable; and a pungent, disagreeable smell. It burns by means of a wick, with the diffusion of a vivid light, and much smoke. It may be mixed with water in all proportions. It is soluble also in acetic acid, oil of almonds, alcohol, and ether, but not in oil of turpentine. It acts upon the animal economy with extreme violence; and in the dose of one drop it kills a dog. It forms salts with the acids. About one part of it may be obtained by very skilful treatment from one thousand of good tobacco.

The tobacco raised in 1847 in the United States, amounted to 220,164,000 lbs., valued at $11,008,220. For 1848, it was—produce 218,909,000 lbs.; value $8,756,360.

The exports during the same were, in value—

1847	$7,242,086
1848	7,551,122

TOBACCO-PIPES are made of a fine-grained plastic white clay, to which they have given the name. It is worked with water into a thin paste, which is allowed to settle in pits, or it may be passed through a sieve, to separate the silicious or other stony impurities; the water is afterwards evaporated till the clay becomes of a doughy consistence, when it must be well kneaded to make it uniform. The clay is distinguished by its perfectly white color, and its great adhesion to the tongue after it is baked; owing to the large proportion of alumina which it contains.

A child fashions a ball of clay from the heap, rolls it out into a slender cylinder upon a plank, with the palms of his hands, in order to form the stem of the pipe. He sticks a small lump to the end of the cylinder for forming the bowl; which having done, he lays the pieces aside for a day or two, to get more consistence. In proportion as he makes these rough figures, he arranges them by dozens on a board, and hands them to the pipemaker.

The pipe is finished by means of a folding brass or iron mould, channelled inside of the shape of the stem and the bowl, and capable of being opened at the two ends. It is formed of two pieces, each hollowed out like a half-pipe, cut as it were lengthwise; and these two jaws, when brought together, constitute the exact space for making one pipe. There are small pins in one side of the mould, corresponding to the holes in the other, which serve as guides for applying the two together with precision.

The workman takes a long iron wire, with its end oiled, and pushes it through the soft clay in the direction of the stem, to form the bore, and he directs the wire by feeling with his left hand the progress of its point. He lays the pipe in the groove of one of the jaws of the mould, with the wire sticking in it; applies the other jaw, brings them smartly together, and unites them by a clamp or vice, which produces the external form. A lever is now brought down, which presses an oiled stopper into the bowl of the pipe, while it is in the mould, forcing it sufficiently down to form the cavity; the wire being meanwhile thrust backwards and forwards so as to pierce the tube completely through. The wire is now withdrawn, the jaws of the mould opened, the pipe taken out, and the redundant clay removed with a knife. After drying for a day or two, the pipes are scraped, polished with a piece of hard wood, and the stems being bent into the desired form, they are carried to the baking kiln. The pipes are then put in the furnace or kiln and baked, removed to receive the glaze (in some instances), and again returned to the furnace till the glaze has melted over the bowl.

TOMBAC. An alloy of copper and zinc, or a species of brass with excess of zinc. When arsenic is added, it forms *white tombac*.

TOOTHING. In architecture, bricks alternately projecting at the end of a wall, in order that they may be bonded into a continuation of it when the remainder is carried up.

TOPAZ. A crystallized mineral harder than quartz, of a yellow or wine color, composed of 60 alumina, 85 silica, 5 fluoric acid. When heated, the Brazilian topaz becomes rose-red, and is sometimes in this state passed off as a ruby: the Saxon topaz loses its color by heat. When without flaws and of a good color, it is much employed in jewelry. The Saxon is usually paler than the Brazilian, which often has a pinkish hue; the Siberian topaz is usually colorless, and the Scotch has a blue tinge.

TOPAZOLITE. A sub-variety of garnet of a pale-yellow color, found in Piedmont. It is a silicate of alumina, lime, and iron, with traces of glucina and manganese.

TORREFACTION. The operation of roasting ores to deprive them of sulphur, arsenic, or other volatile ingredients. When drugs are highly dried, or partially toasted or roasted, they are also said to be torrefied.

TORSION, in mechanics, is the twisting or wrenching of a body by the exertion of a lateral force. If a slender rod of metal suspended vertically, and having its upper end fixed, be twisted through a certain angle by a force acting in a plane perpendicular to its axis, it will, on the removal of the force, untwist itself, or return in the opposite direction with a greater or less velocity, and, after a series of oscillations, will come to rest in its original position. The limits of torsion within which the body will return to its original state depends upon its elasticity. A fine wire, of a few feet in length, may be twisted through several revolutions without impairing its elasticity; and within those limits the force evolved is found to be perfectly regular, and directly proportional to the angular displacement from the position of rest. If the angular displacement exceeds a certain limit, the particles of the body will be wrenched asunder; or if the elasticity is not perfect (as in a wire of lead, for example, before disruption takes place), the particles will assume a new arrangement, or *take a set*, and will not return to their original position on the withdrawal of the disturbing force.

The resistance which cylinders or prisms formed of different substances oppose to torsion, furnishes one of the usual methods of determining the elasticity and strength of materials; and the property which a metallic wire or thread stretched by a small weight possesses of becoming twisted and untwisted in a series of isochronous and perfectly regular oscillations, has been ingeniously applied in the torsion balance to the measurement of very minute forces, and thereby to the establishment of the fundamental laws of electricity and magnetism, and to the determination of the mean density of the earth. (*See* Balance of Torsion.)

The laws of torsion have been experimentally investigated by Coulomb in a variety of substances; as metallic wires, hairs, fibres of silk, &c. The method which he employed consisted in attaching a body of given form and dimensions to the extremity of the wire, and, after twisting it through a certain angle, to abandon it to the action of the force evolved, and observe the time of the oscillations. The following general laws were found to hold good:

1. On loading a wire or thread with different weights, it will settle in different positions of stability; that is to say, an index attached to the weight will point in different directions if the weight be varied, and the angular deviation may amount even to a whole circumference.

2. The oscillations are isochronous.

3. The time of oscillation is proportional to the square root of the weight which stretches the wire.

4. The time of oscillation is as the square root of the length of the wire.

5. The time of oscillation is inversely as the square of the diameter of the wire.

TORTOISE-SHELL, or rather scales, a horny substance that covers the hard strong covering of a bony contexture, which incloses the *Testudo imbricata*, Linn. The lamellæ or plates of this tortoise are 13 in number, and may be readily separated from the bony part by placing fire beneath the shell, whereby they start asunder. They vary in thickness from one-eighth to one-quarter of an inch, according to the age and size of the animal, and weigh from 5 to 25 pounds. The larger the animal, the better is the shell. This substance may be softened by the heat of boiling water; and if compressed in this state by screws in iron or brass moulds, it may be bent into any shape. The moulds being then plunged in cold water, the shell becomes fixed in the form imparted by the mould. If the turnings or filings of tortoise-shell be subjected skilfully to gradually increased compression between moulds immersed in boiling water, compact objects of any desired ornamental figure or device may be produced. The soldering of two pieces of scale is easily effected, by placing their edges together, after they are nicely filed to one bevel, and then squeezing them strongly between the long flat jaws of hot iron pincers. The pincers should be just hot enough to brown paper slightly, without burning it. They may be soldered also by the heat of boiling water, applied along the edges with skilful pressure. But in whatever way this process is attempted, the surfaces to be united should be made very smooth, level, and clean; the least foulness, even the touch of the finger, or breathing upon them, would prevent their coalescence.

Tortoise-Shell, is manufactured in various objects, partly by cutting out the shapes, and partly by agglutinating portions of the shell by heat. When the shell has become soft by dipping it in hot water, the edges are in the cleanest possible state, without grease, pressed together with hot flat tongs, and then plunged into cold water, to fix them in their position. The teeth of the larger combs are parted in their heated state, or cut out with a thin frame-saw, while the shell, equal in size to two combs, with their teeth interlaced, is bent like an arch in the direction of the length of the teeth. The shell is then flattened, the points are separated with a narrow chisel or *pricker*, and the two combs are finished, while flat, with coarse single-cut files and triangular scrapers. They are finally warmed, and bent on the knee over a wooden mould, by means of a strap passed round the foot, just as a shoemaker fixes his last. Smaller combs of horn and tortoise-shell are parted, while flat, by an ingenious machine, with two chisel-formed cutters placed obliquely, so that each cut produces one tooth. (See Rogers' Comb-cutting Machine, *Trans. Soc. Arts* vol. xlix., part 2, since improved by Mr. Kelly.) In making the frames for eye-glasses, spectacles, &c., the apertures for the glasses were formerly cut out to the circular form, with a tool something like a carpenter's centre-bit, or with a crown-saw in the lathe. The discs so cut out were used for inlaying in the tops of boxes, &c. This required a piece of shell as large as the front of the spectacle; but a piece one-third of the size will now suffice, as the eyes are *strained* or *pulled*. A long narrow piece is cut out, and two slits are made in it with a saw. The shell is then warmed, the apertures are pulled open, and fastened upon a taper triblet of the appropriate shape. The groove for the edge of the glass is cut with a small circular cutter, or sharp-edged saw, about three-eighths or half an inch in diameter; and the glass is sprung in when the frame is expanded by heat.

TRACING-PAPER, is made by washing tissue-paper with a mixture of equal parts of spirits of turpentine and mastic-varnish, the transparency being as the varnish.

Artisans transfer drawings to wood, by laying paper covered with soft red chalk, or pipe-clay, on the wood, and then following the lines on tracing-paper with a hard point, so as to impress the same, through the red paper on the wood. This nearly resembles the similar practice in engraving. (*See* LITHOGRAPHY.)

TRAGACANTH. A variety of gum: it is the produce of the *Astragalus Tragacantha*, a native of Africa, and imported in small twisted or flattened pieces, white or yellowish, and translucent or nearly opaque. When put into water they swell up, and gradually form a gelatinous or pasty mass; not dissolving into a clear solution, as is the case with gum arabic. An analogous kind of gum is found in other plants, and the generic name of *tragacanthin* is sometimes applied to it.

It forms a paste which does not crack, nor readily ferment, and hence is put on postage-stamps, labels, &c.

TRANSPARENT BLINDS, are painted with transparent colors on stretched cambric, prepared by a coat of hot solution of isinglass or parchment-glue. The transparent colors are lake, prussian-blue, umber, sienna, and vandyke-brown; and, other colors are made *semi-transparent* when ground with the mastic varnish used in blind-painting.

Transparent blinds are also elegantly made by perforating, or punching with a machine, thin sheets of metal, with such numerous holes that vision is not obstructed by the intermediate divisions. They are now in general use. The same machine has also been applied to make lanterns, cullenders, strainers, dredgers, &c. Wire gauze forms the usual transparent blinds.

TRANSPLANTATION, is an operation whose success depends on the plant being torpid, and on its spongioles being uninjured. If it be growing, or evergreen, and the spongioles are uninjured, the removal will produce no injury except the temporary suspension of the action of the spongioles. Old trees in which the roots are much injured form new ones so slowly, that they are liable to be exhausted of sap by the absorption of numerous young buds before new spongioles can be formed. The amputation of their upper extremities is, therefore, the most probable prevention of death; but in most cases injury to the roots is fatal.

TRIPOLI. A mineral used for polishing, originally from Tripoli in Barbary. It occurs in friable earthy masses of a dull clay color. Its essential components are silica, alumina, and oxide of iron; but the varieties of tripoli appear to vary extremely in composition. Ehrenberg has found the different tripolis to be aggregates of silicified animalcules. It is yellow-gray, or dirty-white in color, and does not adhere to the tongue.

According to the chemical analysis of Bucholz, tripoli consists of—silica, 81; alumina, 1·5; oxide of iron, 8; sulphuric acid, 3·45; water, 4·55. This specimen was probably found in a coal-field. The tripoli of Corfu is reckoned the best for scouring or brightening brass and other metals. (*See* POLISHING.)

TUFA, or TUF. A gray deposit of calcareous carbonate, from springs and streams, generally incrusting twigs and roots of plants in water.

TULA METAL. An alloy of silver, copper, and lead.

TUNGSTEN. A peculiar metal, which occurs in the state of an acid (the *tungstic*), combined with various bases—as with lime, the oxides of iron, manganese, and lead. The metal is obtained by reduction of the ore, or the deoxidizement of the acid, in the form of a dark steel-gray powder, which assumes under the burnisher a feeble metallic lustre. Its specific gravity is 17·22.

TUNNEL. In engineering, a subterranean passage cut through a hill or under a river, for the purpose of carrying a canal, road, railway, &c.

In the construction of railways and canals, it is sometimes absolutely necessary, and very frequently expedient, to have recourse to tunnelling, either to preserve the requisite level, or shorten the distance, or to lessen the expense of open cutting. The circumstances on which the question of expediency depends, are often of a very complicated nature; but, generally speaking, it must be decided by considerations of economy, for in the present state of engineering, a tunnel may be made of almost any length, and through materials of any description, from a granite rock to a quicksand. The nature of the ground can hardly be said to interpose any farther obstacle than what may be occasioned by the expense.

One of the greatest tunnels in the world, is that under the river Thames below London Bridge—a short notice of it is here inserted.

Some previous attempts had been made to carry a tunnel under the river below London Bridge. In 1799, one was projected at Gravesend; but the project was soon abandoned. In 1804, another was attempted from Rotherhithe to Limehouse. A shaft of 11 feet in diameter was sunk to the depth of 42 feet, and continued at a reduced diameter of 8 feet to the depth of 76 feet, whence a drift was carried 923 feet under the river, and to within 150 feet of the opposite shore, where difficulties of so formidable a nature arose that the engineer reported farther progress to be impossible. The scheme, however, continued to be agitated; and in 1823, Mr. Brunel proposed a plan which has at length been carried successfully into execution.

The act of parliament authorizing the operation was obtained in June, 1824, and shortly after the work was commenced at Rotherhithe. The shaft at this place is 150 feet from the river. It was formed by building a cylinder of brickwork 50 feet in diameter, 42 feet in height, and 3 feet in thickness, on the top of which a steam engine was erected for raising the water and earth. The cylinder was let down bodily into the ground, forcing its way through a bed of gravel and sand 26 feet deep, and full of land water. The shaft was sunk to the depth of 65 feet, and from this level another smaller shaft, 25 feet in diameter, was sunk, destined to be a well or reservoir for the drainage of water. The excavation for the body of the tunnel was commenced at a depth of 63 feet, and was carried on at a declivity of 2 feet and 3 inches per 100 feet, in order to have sufficient thickness of ground to pass safely under the river. The excavation is 88 feet in breadth, and 22¼ feet in height, presenting a sectional area of 850 feet; and the base, at the deepest part of the river, is 76 feet below high-water mark. The body of the tunnel is of brickwork in Roman cement.

In the neighborhood of the city of Buffalo, N. Y., is the tunnel of the Water Works Company in the rock under the Erie Canal and the Black Rock harbor to the Niagara river, about half a mile beyond the city line.

The perpendicular shaft or well is about 8 feet in diameter and 30 feet deep, nearly the whole being through rock. From the bottom of the well starts the tunnel, which is nearly circular, and about 6¼ feet in diameter, running nearly horizontally towards the bed of the river, which is distant about 360 feet. A slight slope upward, as the tunnel advances, allows the water which pours into it from springs or crevices in the rock, to run back into the well out of the way of the workmen who are engaged incessantly, day and night, in blasting the rock. They have now (1851) proceeded about 250 feet from the well, progressing at about 2 feet per day. Only four of the miners employed are able to work at once, changing three times during the twenty-four hours. The work is all done by lamp-light.

The Railroad Tunnel at New Hamburg, N. Y., is 830 feet long, and through solid rock. At the south end is a cut 500 feet long, 30 feet wide, and 50 feet deep, all through the rock before reaching the tunnel; through two shafts sunk to it, one 70 feet in depth, the other 56, a glimpse of daylight may be obtained. Emerging at the north end one other deep cut is found, nearly as formidable as that at the south, being 200 feet long and 70 deep, making the entire deep cutting through the rock, all inclusive, no less than 1530 feet.

To carry on this work Messrs. Ward, Wells & Co., the contractors, employ 400 men, keep in steady operation nine blacksmiths' shops with two fires each, to repair and temper tools, have 12,000 lbs. of cast steel in drills and tools in constant use, and have consumed 6000 kegs of powder, of 25 lbs. each, in fourteen months. The tunnel is 19 feet high and 24 feet wide, where finished, and will be so all the way through. It is not yet completed.

The Great Tunnel, of the Baltimore and Ohio Railroad, is one of the greatest works of civil engineering now going on in this country. It is a few miles from

Morgantown, West Virginia, and is through a mountain (for a rail-track) a mile and a quarter wide. There are already sunk three shafts, some 20 by 19 feet, and from 175 to 185 deep.

The Huddersfield and Manchester Railroad Tunnel, in England, is more than three miles in length, being the largest in the world, at a depth of 625 feet below the ridge of the hill, which it pierces. The tunnel is so perfectly straight that on a clear day one can see through from either end.

In France, there is an extensive tunnel three miles in length, on the railroad between Marseilles and Avignon. Its height is 30 feet, and width 24 feet, and its depth below the surface of the ground 600 feet. The cost of tunneling was, $2,040,000.

TURBINE. (*See* WHEELS, WATER.)

TURF. (*See* FUEL and PEAT.)

TURMERIC. The root of the *Curcuma longa.* This root yields a fine yellow powder, which is occasionally used as a dye-stuff in medicine; it also forms one of the ingredients of *curry powder.* Paper stained with turmeric is often used in the chemical laboratory as a test of the presence of free alkalies and their carbonates, by which its yellow color is converted to brown. It is also used ta color butter.

TURNING is a very ingenious and useful art, by which a great variety of articles are manufactured, by cutting or fashioning them while they revolve upon an axis. Every solid substance in nature may be submitted to this process; and, accordingly, we have articles turned in the metals, in wood, in pottery, in stone, in ivory, &c. Among the great varieties of *lathes*, it is indispensably required, for circular turning, that the work should be supported by two steady centres, or by parts equivalent to two centres, at a distance from each other in the axis of rotation, and that the tool should be supported by a steady bar, or a piece called the *rest.*

Clock and watch-makers use a very cheap, simple, and portable lathe, called a *turn-bench*, consisting of a straight bar of iron, about five inches long, with two cross bars or heads, about two inches long, one fixed at the end of the long bar, and the other capable of being shifted by means of a socket and screw. In each of these heads is a centre-pin, terminating in a point at one end, and in a central hole at the other, like the centre-pin in the poppet head of any other lathe; the use of which is to afford point centres when the points are turned towards each other, or hole centres when the contrary is the case; and, lastly, there is a small rest, with its support, slidable and adjustable along the bar, as in another lathe. These instruments will, therefore, support any piece of four or five inches long, and three inches diameter, between the centres; and the method of producing the rotation is by passing the cat-gut string of a bow once or twice round the work, and drawing the bow backwards and forwards with one hand, while the other is employed in applying the tool. The turn-bench itself is held steady in a vice fixed to a bench or stand.

The common lathe of the turners in wood, called the *pole-lathe*, is the same thing as the watchmaker's turn-bench, but upon a large scale, and a little varied. Instead of the horizontal bar, it has two long stout bars of wood, called *shears*, forming what it called the *bed* of the lathe, and its two poppet-heads are upright blocks of wood, mortised in between the shears, above which they rise and carry the centre-screws, and between which they are movable, and may be wedged firmly at any required distance from each other. The work itself is either put between the centres, or upon a wooden mandrel, and is made to revolve by a string or band, proceeding from a long spinning pole at the ceiling or roof of the shop, round the work, and thence to a treddle or foot-board, which acts by alternate pressure from the foot, while the workman applies the cutting tool with his hands.

The velocity of rotation may be extremely swift in wood, slower in brass and bell-metal, still slower in cast-iron, and slowest of all in forged iron or steel. Steel and iron require to be kept wet.

If the poppet-heads, supporting the mandrel, be made regularly to move from side to side, during the rotation, or the rest be made to approach to, and recede from, the work, any number of times in a turn, the cuts will not be circular, but undulating, indented, or waved in any curve that may be required. The motion is commonly regulated by certain round plates of brass fixed on the mandrel, called *roves*, which have their edges waved, and are called *roses.* The largest columns, the most ponderous artillery, and the minutest pivots of watch-work, with all wheel-work, rotatory machines, vessels, &c., are worked by this machine.

Turning of earthenware and porcelain is requisite, to give to circular vessels their correct figure, and proper size and thickness. The lathe has similar arrangement to that for turning wooden-vessels, &c.; with this addition, the treddle has a cross-piece, for convenience of a treader, giving motion more readily to the wheel and spindle, and of properly regulating that motion, while the turner is steadily engaged in his operations. Outside of the head-stock of the lathe, on the screw, is fixed a *chuck*, of the size proper for the inner surface of the edge of the vessel, to fit easily. The turner stands looking towards the headstock (not exactly linear with his lathe, as does the wood-turner), and is separated from the wheel by a wainscot partition, so as to prevent any of the clay-turnings falling on the machinery. The treader stands at the end of the spindle, on a raised position, so that the foot requires the treading, to give force to the treddle. At the side of the treader is a board, on which are the vessels from the thrower, one of which is constantly handed over to the turner as he needs it.

The turner places the vessel on the chuck, and, with his finger, presses its edge firm, or fixed to the clay-ring previously formed on it, the treader gives motion to the spindle, and the turner, by his tools of very thin steel, varying in breadth for the several vessels, carefully abstracts all the surplus clay left by the thrower, and likewise adds all the elegance the pattern suggests; and, after this is finished, the treader expertly gives to the spindle a retrograde motion, during which the turner applies the flat surface of his tool to the vessel, and thereby gives the whole a solidity not previously existing, and also a glossy smoothness, preventive of any inequalities the prior operation might have left. It will be readily conjectured, that this manipulation affords much opportunity for exercising taste and genius, and requires considerable practice, to prevent the articles being fractured and destroyed.

In manufactories, where the lathes have motion from a steam-engine, the lathes are so constructed as to receive increased velocity for those parts of the operation which require it. There is a general spur, or driving-shaft, along the room, nigh the wall, and a drum fixed on it, over each lathe, over which a belt passes. The lathe has a small shaft fixed parallel to its spindle, with one fixed and two loose pulleys: from the drum, the belt passes round the fixed pulley, which will give motion to either of those loose that may be geared with it. One of these gives the direct motion to the spindle, and the other, to the crossed belt, gives the retrograde.

Some articles, after being taken off the turner's lathe, are only required to be gradually dried, to be ready for being baked in the biscuit-oven; others require to be *ornamented*, *figured*, or *hurdled*, and are placed where they will not dry quickly.

Many articles of a circular figure, and some *hollow-ware*, of even oval, are formed and finished on a mould, placed on the head of a vertical spindle, moved by a winch (not dissimilar to a lapidary's wheel), and a larger of clay (butted, as described under *pressing*), is laid on the mould, and, by swage and sponge, as the spindle revolves, has the full thickness and shape, at the same operation, completed. This is much used to fabricate saucers and plates.

TURPENTINE is the substance which flows from incisions made in the stem of the pine species. It has the consistence and color of honey, a peculiar smell, a warm and bitter taste; it dries in the air: it melts at a gentle heat, and burns when ignited with a bright sooty flame. There are several varieties, as—1. *Common turpentine*, obtained from *pinus abies* and *silvestris*: it consists of spirits of turpentine (volatile oil), from 5 to 26 per cent.; and of resin or colophony.—2. *Venice turpentine*, is extracted from the *pinus larix* (larch), and the French turpentine from the *pinus maritama*. The first comes from Styria, Hungary, the Tyrol, and Switzerland, and contains from 18 to 25 per cent. of oil; the second, from the south of France, and contains no more than 12 per cent. of oil. The oil of all the turpentines is extracted by distilling them along with water. They dissolve in all proportions in alcohol, without leaving any residuum. They also combine with alkaline leys, and in general with the salifiable bases. Venice turpentine contains also succinic acid.—3. Turpentine of Strasbourg is extracted from the *pinus picea* and *abies excelsa*. It affords 33·5 per cent. of volatile oil, and some volatile or crystallizable resin, with extractive matter and succinic acid.—4. Turpentine of the Carpathian mountains, and of Hungary; the first of which comes from the *pinus cembra*, and the second from the *pinus mugos*. They resemble that of Strasbourg.—5. Turpentine of Canada, called Canada balsam, is extracted from the *pinus canadensis* and *balsamea*. Its smell is much more agreeable than that of the preceding species.—6. Turpentine of Cyprus or Chio, is extracted from the *pistacea terebinthus*. It has a yellow, greenish, or blue-green color. Its smell is more agreeable, and taste less acrid, than those of the preceding sorts.

The pine forests of Carolina and Florida supply this country with all its turpentine. The export trade is considerable.

TURPENTINE, OIL OF, sometimes called essence of turpentine. As found in commerce, it contains more or less rosin, from which it may be freed by redistillation along with water. It is colorless, limpid, very fluid, and possessed of a very peculiar smell. Its specific gravity when pure, is 0·870. It always reddens litmus paper, from containing a little succinic acid. According to Oppermann, the oil which has been repeatedly rectified over chloride of calcium, consists of 84·60 carbon, 11·735 hydrogen, and 8·67 oxygen. When oil of turpentine contains a little alcohol, it burns with a clear flame; but otherwise it affords a very smoky flame. Chlorine inflames this oil; and muriatic acid converts it into a crystalline substance, like camphor. It is employed extensively in varnishes, paints, &c., as also in medicine.

The spirit, or oil of turpentine, is obtained from the crude article by distillation. When the volatile oil comes over, and colophony is left behind in the retort; 250 lbs. of turpentine yield 60 lbs. of oil.

A patent was granted in 1847, for refining turpentine for the production of the pine oil, as it is termed, for burning in lamps. The resinous matter is separated by treating the turpentine with potassa, and in order to effect thorough admixture the liquid is forced through a succession of fine strainers. After this operation, rain-water is added, and the whole suffered to stand for twelve hours, when the pure spirits will be found floating above the water and impurities, from which it is drawn off.

A patent has been granted for an improvement in the distillation of crude turpentine, consisting merely of an agitator or stirring apparatus, working without the still, the shaft of the agitator passing through a stuffing box in the top of the still.

The stirring of various liquids in the operation of boiling is a common device, but has never been before applied in the production of turpentine, and is in this case, as asserted, attended with considerable advantages. Turpentine consists of two liquids, one boiling at a much higher temperature than the other, which is obvious from the very interesting fact, that while boiling without pressure its temperature may be raised more than 200°.

Mr. Violette has adopted the process of distillation with steam, which he found so successful in the case of quicksilver (*see* MERCURY), to the treatment of turpentine with great economy of time and fuel, and obtains a purer article. It is asserted that in this country Mr. Wade distilled turpentine with steam so long as three years back.

TYMPANUM, in architecture, the space in a pediment enclosed by the cornice of the inclined sides, and the horizontal fillet of the corona.

TYPES. By this term is understood the letters, from the smallest size to the largest, with which books and other articles are printed. A single type consists of the shank, the beard, and the face. The shank is the body of the letter; the beard is that part between the shoulder of the shank and the face; the face is the shape of the letter, from which the impression is taken.

The first care of the letter-cutter is to prepare well-tempered steel punches, upon which he draws or marks the exact shape of the letter, with pen and ink if it be large, but with a smooth blunted point of a needle if it be small; and then, with a proper sized and shaped graver and sculptor, he digs or scoops out the metal between the strokes upon the face of the punch, leaving the marks untouched and prominent. He next works the outside with files till it be fit for the matrix. Punches are also made by hammering down the hollows, filing up the edges, and then hardening the soft steel. Before he proceeds to sink and justify the matrix, he provides a mould to justify them by.

A matrix is a piece of brass or copper, about an inch and a half long, and thick in proportion to the size of the letter which it is to contain. In this metal the face of the letter intended to be cast is sunk, by striking it with the punch to a depth of about one-eighth of an inch. The mould in which the types are cast, is composed of two parts. The outer part is made of wood, the inner of steel. At the top it has a hopper-mouth, into which the fused type-metal is poured. The interior cavity is as uniform as if it had been hollowed out of a single piece of steel. From the pot, over the furnace, containing the type metal fused, a small iron ladle lifts as much as will cast a letter. The metal is poured into the matrix, and with a jerk of the hand the metal is carried round the matrix, and made to fill all its crevices perfectly. A tail of metal hangs to the type as it quits the mould. There are nicks on the lower edge of the type, to enable the compositor to set them upright without looking at them.

The tails are next removed, and the broad sides of the type rubbed on a grit-stone. They are then set up in a frame with the nicks outward, when they are polished on each side and groved at the bottom, to make them stand more readily. They are then tied up in lines of suitable length.

Machines for type-making are commencing to be used, and, instead of a fused metal being used, a rod of copper or other metal is pressed by machinery on a steel die having the letter cut into it.

TYPE METAL. The alloy of lead and antimony used in casting printers' types. One part of antimony to three of lead are the usual proportions. This alloy takes a sharp impression from the the mould or matrix, and is hard enough to stand the work of the press, without being brittle or liable to fracture.

Besides the above proportion, the following is often followed:—Put into a crucible 10 lbs of lead, and when it is in a state of fusion, throw in 2 lbs of antimony; these metals in such proportions form the alloy of which some printing types are made. The antimony gives a hardness to the lead, without which the type would be speedily rendered useless by the printing press. Different proportions of lead, copper, brass, and antimony, frequently constitute this metal. Every artist has his own proportions, so that the same composition cannot be obtained from different foundries.

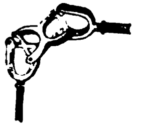
ULTRAMARINE is a beautiful blue pigment obtained from the variegated blue mineral, called lazulite *(lapis lazuli)*, by the following process:—Grind the stone to fragments, rejecting all the colorless bits, calcine at a red heat, quench in water, and then grind to an impalpable powder along with water, in a paint-mill, or with a porphyry slab and muller. The paste, being dried, is to be rubbed to powder, and passed through a silk sieve. 100 parts of it are to be mixed with 40 of rosin, 20 of white wax, 25 of linseed oil, and 15 of Burgundy pitch, previously melted together. This resinous compound is to be poured hot into cold water; kneaded well first with two spatulas, then with the hands, and then formed into one or more small rolls. MM. Clement and Desormes, who were the first to divine the true nature of this pigment, think that the soda contained in the lazulite, uniting with the oil and the rosin, forms a species of soap, which serves to wash out the coloring-matter. If it should not separate readily, water heated to about 150° F. should be had recourse to. When the water is sufficiently charged with blue color, it is poured off and replaced by fresh water; and the kneading and change of water are repeated till the whole of the color is extracted. The first waters afford, by rest, a deposite of the finest ultramarine; the second, a somewhat inferior article, and so on. Each must be washed afterwards with several more waters, before they acquire the highest quality of tone; then dried separately, and freed from any adhering particles of the pitchy compound by digestion in alcohol. The best *ultramarine* is a splendid blue pigment, which works well with oil, and is not liable to change by time. Its price in Italy was 26 dollars the ounce, a few years ago, but it is now greatly reduced.

The blue color of *lazulite* had been always ascribed to iron, till MM. Clement and Desormes, by a most careful analysis, showed it to consist of—silica, 34; alumina, 33; sulphur, 3; soda, 22; and that the iron, carbonate of lime, &c., were accidental ingredients, essential neither to the mineral, nor to the pigment made from it. By another analyst, the constituents are said to be—silica, 44; alumina, 35; and soda, 21; and by a third, potassa was found instead of soda, showing shades of difference in the composition of the stone.

Till a few years ago, every attempt failed to make ultramarine artificially. At length, in 1828, M. Guimet resolved the problem, guided by the analysis of MM. Clement and Desormes, and by an observation of M. Tassaert, that a blue substance like ultramarine was ocasionally produced on the sandstone hearths of his reverberatory soda furnaces. M. Guimet has kept his process secret. M. Gmelin of Tübingen, has published a prescription for making it: which consists in enclosing carefully in a Hessian crucible a mixture of two parts of sulphur, and one of dry carbonate of soda, heating them to redness till the mass fuses, and then sprinkling into it by degrees another mixture, of silicate of soda, and aluminate of soda; the first containing seventy-two parts of silica, and the second seventy parts of alumina. The crucible must be exposed after this for an hour to the fire. The ultramarine will be formed by this time; only it contains a little sulphur, which can be separated by means of water. M. Persoz, professor of chemistry at Strasbourg, has likewise succeeded in making an ultramarine. Lastly, M. Robiquet has announced, that it is easy to form ultramarine, by heating to redness a proper mixture of kaolin (China clay), sulphur, and carbonate of soda.

UMBER is a massive mineral; fracture large and flat; conchoidal in the great, very fine earthy in the small; dull; color, liver, chesnut, or dark yellowish brown; opaque; does not soil, but writes; adheres strongly to the tongue, feels a little rough and meagre, and is very soft; spec. grav. 2·2. It occurs in beds with brown jasper in the Island of Cyprus, and is used by painters as a brown color, and to make varnish dry quickly.

UNIVERSAL JOINT, or HOOKE'S JOINT. In machinery, an ingenious contrivance of Dr. Hooke for the purpose of communicating motion obliquely. It is single or double.



URANIUM. A metal discovered by Klaproth in 1789, who named it after the planet Uranus, discovered about that time. It occurs only in two native combinations—the *pechblende* of Saxony, and the *uranite;* of the latter, fine specimens have been found in Cornwall. Little is known of the properties of metallic uranium: it appears to be a brittle gray metal, of the spec. grav. of about 9. From the experiments of Berzelius and Arfwedson we deduce the number 217 for its equivalent; that of its protoxide being 225, and of its peroxide (sesquioxide) 229. The salts of the oxides of uranium are of a fine grass green or yellow color: the persalts have been most examined. Ferrocyanate of potassa produces in them a very characteristic rich brown precipitate, not unlike that formed by the persalts of copper. They are also precipitated brown by infusion of galls.

UREA. A peculiar crystallizable substance held in solution in the urine. When dried in vacuo it consists, according to Dr. Prout, of—

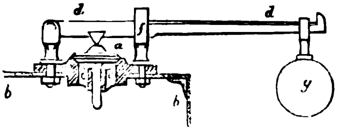
	Atoms.	Equiv.	Theory.	Experiment.
Nitrogen...	2	28	46·67	46·66
Carbon	2	12	20·00	20·07
Hydrogen..	1	4	6·67	6·65
Oxygen....	4	16	26·66	26·63
	1	60	100·00	100·00

Urea is readily soluble in water, tasteless, inodorous; and when mixed with the other contents of the urine very prone to putrefaction, the principal result of which is carbonate of ammonia. Urea has been artificially obtained by the action of ammonia on cyanate of lead; oxide of lead is precipitated, and colorless crystals of urea obtained by carefully evaporating the solution.

URIC ACID. Found abundantly in the excrement of serpents and in guano. In the latter it exists often to the amount of 40 per cent. as urate of ammonia, and free uric acid. It is by decomposition broken up, first into oxalate, and then into carbonate of ammonia. It consists of $C_{10} H_4 N_4 O_6$.

VALONIA. A kind of acorn, imported from the Levant and the Morea for the use of tanners, as the husk or cup contains abundance of tannin.

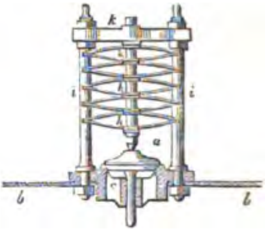
VALVE. In mechanics, a close lid affixed to a tube, or hollow piston, or opening in a vessel, by means of a hinge or other sort of movable joint, in such a manner that it can be opened only in one direction. For the passage of water, the clack-valve, made of leather and wood, is generally used, working on a side-axle, or a central-axle, or pyramidical. A steam-valve is a flat metal plate, bevelled at the edges and guided by a pin, as an axis. In air-pumps they are of oiled silk, with a grating. But, for every purpose, caoutchouc is the best material. In the great London works, valves are as much as 30 inches in diameter; and the great column of water makes them act with astonishing force. A spherical ball of metal laid on the end of a tube properly formed, and retained in its place by its weight alone, is sometimes used advantageously instead of a valve, as in the *hydraulic ram.* The *safety valve* of the steam engine is a valve attached to the boiler, to obviate the danger of its bursting in case the steam should become too strong. The valve is so loaded that its weight, added to that of the atmosphere, exceeds the pressure of the steam, when of a sufficient force. When the expansive force increases so far that its pressure preponderates over the pressure of the atmosphere and the weight of the safety valve, the valve opens, and the steam escapes from the boiler till its elastic force is sufficiently diminished, and the valve shuts by its own weight. By opening the safety valve the engine may be stopped at pleasure, for which purpose a particular apparatus is attached to the valve. As any accidental derangement of the safety valve might be attended with the most disastrous consequences, it has been proposed to make the valve of a metal which melts at a particular temperature, by which means the elastic force of the steam could never exceed that which corresponds to the temperature at which the valve would melt. This method has been adopted in France.



Duplex Safety Valve. This valve is the invention of Mr. S. A. Williams, of Cornwall, Wales. Its object is to prevent the ordinary valve from adhering to its seat, when, from any cause, the internal pressure falls below the atmospheric pressure, and also to indicate the quantity of water in the boiler, to prevent it from getting too low. The common safety valve opens in the usual way, and is linked to a weighted lever *d*, *g*. The weighted lever is extended to the other side, beyond the fulcrum, to a distance equal to that of its distance from the valve. There is a small valve linked to this opposite end of the lever. It is placed inside of the manhole lid, opening downwards. Any upward movement of the valve produces a corresponding downward movement of the smaller valve. The internal pressure tending to open the valves, will be exerted only on the excess of the area of the larger valve over the area of the smaller one. A chain is connected to a float and the small valve. When the float is kept up by the water, the chain is loose, but when the water falls below the proper limit, the small valve is drawn down, and the other valve up, thus blowing off at once a great deal of steam. This valve is somewhat interesting as being a very neat modification of the equilibrium valve.

Frequently a narrow bar of metal is made fast across a circular orifice in the direction of the diameter, and 2 semicircular valves of leather, each of which is covered above and below with a brass plate of the same form, turn on the sides of the bar as on hinges. This is called the *double check* or *butterfly valve*.

When instead of bars of metal the resistance of the valve is afforded by a spring, this is the spring valve, an illustration of which is given here.



VANADIUM. A metal discovered in 1830, by Professor Seftström of Fahlun, in iron prepared from the iron ore of Taberg in Sweden. Vanadium has also been found in a lead ore from Wanlockhead in Scotland, and in a similar mineral from Zimapan in Mexico. Vanadium is a white brittle metal, very difficult of reduction; not oxidized by air or water; and insoluble in sulphuric, muriatic, and hydrofluoric acids; but soluble in nitric and nitromuriatic acids, with which it yields solutions of a fine dark blue color. It is not acted upon by boiling caustic potash, nor by the carbonated alkalies at a red heat. The peroxide of vanadium is of an orange color, and very slightly soluble in water; it unites with the salifiable bases; with the alkalies its salts are soluble, with the other bases sparingly soluble. These salts are orange or yellow colored; in these and other respects there is a close resemblance between vanadium and chromium. Peroxide of vanadium, or vanadic acid, is distinguished from chromic acid by the action of deoxidizing substances, which give a blue solution with vanadium, but a green one with chromium. When heated with borax in the reducing flame of the blowpipe, both of the acids yield a green glass; but in the oxidizing flame the bead becomes *yellow* if vanadium is present, but the green color is, permanent if produced by chronium. According to the experiments of Berzelius, the equivalent of vanadium is about 68; and the protoxide, the deutoxide, and the vanadic acid, are composed respectively of 1 atom of vanadium, and 1, 2, and 3 of oxygen. It exists in the copper of Lake Superior.

VANE. A contrivance for showing the direction of the wind. It consists usually of a thin slip of wood or metal, attached to a perpendicular axis, round which it moves freely; and is so shaped that it presents always the same extremity to the point of the horizon from which the wind blows.

VANILLA. The succulent fruit of a plant of the Orchidaceous order, climbing over trees in the tropical parts of this continent after the manner of ivy. Its fragrance is owing to the presence of benzoic acid, crystals of which form upon the pod if allowed to be undisturbed. It is an aromatic, employed in confectionary and the preparation of liqueurs, and in flavoring of chocolate, ice-cream, &c.

VARNISH. A fluid which when spread thin upon a solid surface becomes dry, and forms a coating impervious to air and moisture. There are two kinds of varnish, namely, *spirit* and *oil varnishes:* rectified alcohol is used for the former; and for the latter fixed and volatile oils, or mixtures of the two. The solid substances dissolved in the above menstrua, and which constitute what is termed the body of the varnish, are almost exclusively resinous, and are chiefly the following: 1. *Turpentine*, all the varieties of which are employed by the varnisher: they form an excellent body, and give strength and glossiness at a small expense; but they do not dry without other additions. 2. *Copal*, a peculiar resin, very difficult to dissolve, but forming a hard and durable ingredient. It is generally melted over a gentle fire previous to use. 3. *Lac*, which gives great toughness and hardness; but is often inadmissible, on account of its reddish-brown color. 4. *Mastic*, which yields a tough, hard, brilliant, and colorless varnish. 5. *Elemi*, a resin of a pale yellow green tint, and a valuable ingredient on account of its toughness and durability. 6. *Sandarach*, a resin which imparts splendor, but which alone is not durable. 7. *Amber*, a valuable ingredient, on account of its hardness and durability; but difficult of transparent solution, and hence chiefly used in opaque varnishes. 8. *Benzoin*, added on account of its fragrancy. 9. *Anime*, which gives brilliancy and some scent. 10. *Gamboge*, for yellow varnishes. 11. *Dragon's blood*, for red varnish. These, together with turmeric, saffron, and annotta, are chiefly used on account of their color, and to cover brass and copper under the name of *lacquers*. 12. *Caoutchouc*. This extraordinary vegetable product has of late been much employed in a variety of preparations used as varnishes. It is invaluable where materials are to be rendered air-tight, as balloons, for example, and where at the same time flexibility, and even elasticity, are required; but its principal application in this way is in the manufacture of various *water-proof* articles. 13. *Asphaltum*, the varieties of which are indispensable in black oil varnishes. In making spirit varnishes, the strongest alcohol of commerce should be used (of a specific gravity not exceeding 820), and its solvent power over some of the more intractable resins is sometimes improved by the addition of a little camphor; in order to prevent the agglutination of the resin, it is often requisite to mix it with sand or pounded glass, by which the surface is much increased, and the solvent energy of the spirit facilitated. The proportions in which the several ingredients are used, and the selections for particular purposes, are infinitely various. The following are a few good varnishes, in illustration of their varieties: 1. *Spirit varnish*. Sandarach 4 oz., seed lac 2 oz., elemi 1 oz., digest the whole in a quart of moderately warm alcohol, and when dissolved add Venice turpentine, 2 ozs. 2. *Lac varnish*. Seed lac 8 oz.; digest for four days in a warm place with a quart of alcohol, and then strain through flannel. 3. *Turpentine varnish*. Mastic 12 oz., mixed with 5 oz. of pounded glass, and digested in a quart of oil of turpentine, adding at intervals about half an ounce of camphor in small pieces. When the mastic is dissolved, add to the warm fluid an ounce and a half of previously liquefied Venice turpentine, and stir the whole together. 4. *Copal varnish*. Copal which has been previously melted by a gentle heat 3 oz., oil of turpentine 20 oz. (measure): put the oil into a flask placed in boiling water, and add the powdered copal in small portions at a time, so that it may be gradually dissolved; let it stand a few days to clear, and then pour it off, and if too thick for use, add to it a little warm oil of turpentine. This varnish dries slowly, but is very durable. 5. *Linseed varnish.* Melt 16 oz. of copal in an iron pot with as gentle a fire as possible, and when fused pour in 8 oz. of hot linseed oil; stir the mixture, remove it from the fire, and while yet warm gradually add a pint of warm oil of turpentine; when the whole is incorporated, strain it through a pice of linen into phials. This is a hard and durable, but also a colored varnish. 6. *Amber varnish.* Melt 16 oz. of amber in an iron pot, then add two oz. of melted lac, and 10 oz. of hot, drying linseed oil; incorporate the whole by stirring; remove it from the fire, and before it cools add a pint of warm oil of turpentine. 7. *Black varnish.* Melt 16 oz. of amber in an iron pot, and add half a pint of hot, drying linseed oil, 3 oz. of powdered rosin, and 3 oz. of powdered asphaltum; stir all together, and when removed from the fire and sufficiently cool, add a pint of warm oil of turpentine. 8. *Lacquer.* Digest 3 oz. of seed lac, 1 oz, of turmeric, and 2 drs. of dragon's blood for six days in a pint of alcohol, frequently shaking the bottle, which should be kept in a warm place; strain the lacquer through linen. The above are samples of each of the principal varnishes; but every maker varies the proportions, and often the nature of the ingredients. In the preparation of varnishes, in consequence of the highly combustible nature of all the materials, the utmost care is requisite to avoid accidents by fire.

White Polishing Varnish. In a quart of alcohol mix 8 oz. of juniper gum, 2 oz. of mastic in tears, 1 oz. of gum elemi, and 4 oz. of Strasburgh turpentine, For metal, with pumice-powder. In this dissolve 1 oz. of copal, in fine powder, and filter. In one pint of alcohol dissolve 1 oz. of gum elemi: mix the two liquids. *Or*, (*for Pictures.*) In one pint of alcohol dissolve ½ oz. of camphor, which mix with 4 oz. of coarse powder of copal, and, by heat, form the mixture, till whatever bubbles arise may easily be counted. Cool, decant, and add more alcohol, to be similarly treated, till there is no residuum. *Or* (*for Metals, Chairs, &c.*) Mix well 4 oz. of powder of glass, (or potter's flint,) 2½ oz. of Strasburgh turpentine, 3 oz. of gum mastic, 6 oz. of gum sandarac, and 3 oz. of copal, melted and dropped into water. Add the whole to 1 quart of alcohol.

Copal Varnish (*Sheldrake's*). Take of copal, broken into small pieces, 2 oz., spirit of ammonia 2 oz., or camphor 2 drs., rectified oil of turpentine 1 pint. Stop the vessel, with a cork cut in grooves, to admit a portion of the heated vapors to escape; bring it to boil over a brisk fire, so that the bubbles may be counted as they rise; keep the mixture at the same heat; for, if the least irregularity, or overheating, takes place, it is useless to proceed. When the solution is complete, let the vessel be quite cool before it is opened. The vessel is of tin, or other metal, strong, shaped like a wine-bottle with a long neck, and capable of holding two quarts.

Copal varnish may be dissolved on pictures, &c. by a boiling solution of an eighth of ammonia, in oil of turpentine, but it requires very skilful management.

Japanner's Copal Varnish. In a glass matrass melt and evaporate 4 lbs of copal, and pour in 1 pint of boiling hot linseed-oil; remove the matrass, and, while hot, add equal weight of oil of turpentine.

Gold Varnish, for Leather. In 2 pints of oil of turpentine mix 1½ scrs. of gamboge and turmeric each, 4 oz. each of seed lac and gum sandarac, ½ oz. of dragon's blood, 2 oz. of turpentine, and 4 oz. of pounded glass, (or potter's flint)—use the clear.

Varnish for Colored Drawings. Mix 1 oz. of Canada balsam and 2 oz. of oil of turpentine. Size first with isinglass, and dry before using the varnish.

Indian Varnish. In 1 quart of alcohol, by a gentle heat, dissolve 5 oz. of shell lac and of seed lac. Strain for use.

Hard Spirit Varnish. In 1 quart of alcohol dissolve 8 oz. of seed lac and of yellow rosin.

Black Varnish. In 1 quart of alcohol dissolve 4 oz. of gum sandarac, and 2 oz. of yellow rosin; then add one oz. of lamp-black. *Or*, alcohol and black sealing-wax, to color it.

To make Caoutchouc Varnish. Melt the caoutchouc in a close vessel, at nearly the temperature to melt lead, and stir it. Oil of turpentine should be carefully added to it, which will render it easily applicable, and leaves the substance, when dry, a firm varnish, impermeable to moisture. It is an excellent varnish, for preserving iron and steel from rust; and it may be removed by a soft brush, dipped in oil of turpentine. A solution of caoutchouc, in five times its weight of oil of turpentine, and this solution mixed with eight times its weight of drying linseed-oil, by boiling, forms the varnish usually applied to air-balloons. *Or*, Digest 1 oz. of caoutchouc, cut into small pieces, in 82 oz. of naphtha; and, when it is dissolved, strain the varnish through a linen cloth.

Oil of Tar, for Common Varnishes, may be employed instead of naphtha.

Varnish for Iron or Wood. Dissolve ½ pint of alcohol in a gallon of wood tar.

Red Varnish, (for Cabinet-work and Violins.) In 1 quart of alcohol dissolve 2 oz. of Strasburgh turpentine, 1 oz. of mastic and of choice benjamin, 2 oz. of seed lac, and 4 oz. of gum sandarac. *Or, (for Metals.)* In 1 quart of alcohol dissolve 6 oz. of Venice turpentine, 4 oz. of brown rosin, 2 oz. of shell lac, and 8 oz. of gum sandarac.

Spirit Varnish, for Colors on Wood. In a matrass, capable of containing two Paris pints of liquid, put a pint, or about 2 lbs., of good spirit of wine, and throw in 4 oz. of shell lac, broken into small bits, together with 2 oz. of gum sandarac, and 1 oz. of gum mastic in tears, grossly powdered; you also add 1 oz. of oil of spike, and place the vessel upon a ring of straw, laid upon the bottom of a boiler filled with water; the whole must be then heated in a furnace over a charcoal fire, and the contents be stirred from time to time, until the gums are entirely melted; but care is to be taken that the spirit of wine be not heated to its boiling-point. This varnish, when cold, is fit to mix with lamp-black, vermilion, or other opaque colors; but, when it is to be used alone, to give a fine polish, it should be filtered, either through cotton or filtering paper.

Varnish for out-door Painting. Boil half a gallon of linseed oil in an iron pot, for an hour, and then lay in it a round of crum of bread, to absorb the fat, and boil some time. Take out the bread, and put in a lb. of powdered rosin gradually, and stir with an iron spatula. Add 4 oz., or more, of the spirits of turpentine, and strain it. It bears weather, wear, and hot water. The same may also be made of 1 oil of turpentine and 4 rosin, well boiled. *Or*, by boiling 16 drying linseed-oil, 8 of gum sandarac, and 1 of oil of turpentine.

It is usual, in the manufacture of spirit varnishes, to mix glass or sand with the resin, for the purpose of affording ready access of the alcohol to all parts of the solid mass. M. Ferrari, however, recommends that, in place of these substances, coarsely powdered charcoal should be used; for the glass or sand frequently tends to aggregate the resin at the bottom of the vessels and protect it from the solvents, whilst, on the contrary, the charcoal rather tends to raise and divide it. The most advantageous proportion appears to be about 1 oz. of charcoal to 1 lb. of the spirits or the oil of turpentine.

To Varnish Silk. If the surface of the silk be pretty large, it is made fast in a wooden frame furnished with hooks and movable pegs. A certain quantity of a soft paste, composed of linseed-oil, boiled with a fourth part of litharge, white of Troyes, Spanish white or tobacco-pipe clay, lamp-black and litharge, is then prepared, in nearly the following proportions: tobacco-pipe clay, dried and sifted through a silk sieve, 16 parts; litharge, ground with water, dried and sifted in the same manner, 8 parts; lamp-black, 1 part. This paste is then spread in an uniform manner over the surface of the silk, by means of a long knife, having a handle at each extremity.

In summer, 24 hours are sufficient for drying, and when dry, the knots produced by the inequalities of the silk are smoothed with pumice-stone. This operation is performed with water; and, when finished, the surface of the silk is washed. It is then suffered to dry, and copal varnish applied.

If it be intended to polish this varnish, it will be proper to apply a second stratum; after which it is polished with a ball of cloth and very fine tripoli, or with a piece of strong cloth only. The varnished silk which results from this process is very black, exceedingly pliable, and has a fine polish. It may be rumpled any way without retaining any fold, or the mark of a fold.

Varnished silk, which has a yellowish color, is prepared with a plain varnish. The silk is covered with a mixture of three parts of boiled oil of poppy, and one part of fat copal varnish, which is spread with a coarse brush, or with a knife. Two coats are sufficient, when the oil has been freed from its greasy principles over a slow fire, or when it has been boiled with a fourth part of its weight of litharge.

White Varnish. In 1 quart of alcohol mix 1 lb. of juniper gum and 6 oz. of Strasburgh turpentine. For wood, linen, and paper.

White Hard Varnish. Pulverize 8 oz. of cullet (flint glass, or use 3 oz. of potter's dried flint); mix with 4 oz. of mastic, and 2 oz. of juniper gum and of Venice turpentine, which put into 1 quart of alcohol. For cards, sheaths, &c.

VARVICITE. An ore of manganese found at Hartshill in Warwickshire, Eng. appears to be a compound of 2 equivalents of peroxide and 1 of sesquioxide of manganese with 1 of water.

VEGETABLE ALKALOIDS. Under the title of *vegetable alkaloids* are comprehended those proximate principles which are possessed of alkaline properties. They all consist of carbon, hydrogen, oxygen, and nitrogen, and they are decomposed with facility by nitric acid, and by heat; and ammonia is always one of the products of the destructive distillation. As they agree in several of their leading chemical properties, the mode of preparing them, with slight variation, is general. The substance containing the alkaline principle is digested, or, more commonly, macerated, in a large quantity of water, which dissolves the salt, the base of which is the vegetable alkali. On adding some more powerful salifiable base, such as potash or ammonia, or boiling the solution, for a few moments, with lime or pure magnesia, the vegetable alkali is separated from its acid; and, being in that state insoluble in water, may be collected on the filter, and washed. To purify it from certain oleaginous, resinous substances, and coloring matters, it is mixed with a little animal charcoal, and dissolved in boiling alcohol. This solution is filtered while hot, and evaporated to dryness, which affords the alkali in a state of perfect purity. Upwards of twenty of these bodies have already been investigated; as morphia, cinchonia, quinia, strychnia, brucia, veratria, and sanguinaria.

VELOCIPEDE. A vehicle invented at Mannheim in 1817, by M. Drais, consisting of a piece of wood about five feet long, and half a foot wide, resting on two wheels, one behind the other. On this an individual sits, as on horseback, his feet touching the ground, and thus propelling the machine. The front wheel may be turned at pleasure, so that the rider may give any direction to the machine. This species of vehicle never came into general use; but it was improved by Knight in England, and a patent received for it.

VELLUM. A fine kind of parchment made of calf-skin. The skins are limed, shaved, washed, and stretched in proper frames, where they are scraped with the currier's fleshing-tool, and ultimately rubbed down to a proper thickness with pumice.

VELVET. This beautiful substance is mostly a silk fabric, remarkable for the softness of its surface. This softness is owing to a loose *pile* or surface of threads, occasioned by the insertion of soft pieces of silk thread doubled under the shoot, weft or cross threads. These stand upright so thickly as entirely to conceal the interlacing of the warp and shoot. The richness of the velvet depends upon the closeness of the pile-threads. The insertion of these short threads is effected in the following manner:

Instead of having only one row of warp threads, which will be crossed alternately over and under by the shoot, there are two sets, one of which is to form the regular warp, while the other is to constitute the pile, and these two sets are so arranged in the loom as to be kept separate. The quantity of the pile-thread necessary is very much more than that of the warp thread, and therefore must be applied to the loom by a different agency. If the pile-threads were worked in among the shoot, in the same way as the warp-thread, the fabric would be simply of a kind of double silk, but without any kind of pile; the pile-threads are therefore formed into a series of loops, standing up from the surface of the silk; and by subsequently cutting these loops with a sharp instrument, the pile is produced. Thin brass wires are temporarily woven in among the weft-threads to assist in forming the loops; and by a delicate cut or scission made with a sharp instrument, the loops are cut and the wires liberated. Striped velvets are produced by some of the pile-threads being uncut.

VENICE SOAP, AND MOTTLED CASTILE SOAP, are merely olive-oil and soda, with a little sulphate of iron in solution, or sulphate of zinc.

VENTILATOR. Any machine or contrivance for promoting or regulating ventilation. The common ventilator placed in windows, which revolves in the same manner as a smoke-jack, in consequence of the impulsion of a current of air, serves only to retard, in some degree, the entrance of the current, to disperse it in different directions, and to prevent any sudden increase in the intensity of the draught. It has no power of acting so as to create a current, or keep up its intensity when it has been established.

VENTILATION. This word literally signifies fanning or blowing. In domestic economy, it is the art of conveying currents of fresh air through close apartments or confined places, so as to maintain the atmosphere in a state of purity.

Atmospheric air consists of two ingredients, oxygen and azote, blended together in the proportion of one part by measure of the former to four of the latter. When these proportions are altered, air becomes unfit to respiration; and when the oxygen is withdrawn or consumed, it is rendered altogether incapable of supporting animal life or combustion. But there are operations both of nature and art continually going forward in which the oxygen of the atmosphere is consumed, and gaseous products evolved which are destructive of life. Thus, in the act of respiration, a certain portion of the oxygen contained in the air inhaled into the lungs is converted into carbonic acid, a substance which acts as a narcotic poison; and hence, in a confined apartment, air is soon rendered, by breathing alone, not merely incapable of maintaining life, but highly destructive of it, in consequence of the evolution of a deleterious gas. In like manner, oxygen is consumed, and carbonic acid evolved, in the process of combustion; and the burning of a pan of charcoal in a close room is known to be a certain means of extinguishing life.

Although a decomposition and deterioration of air is thus continually going forward, nature has by various means provided so effectually for the restoration of the two constituent gases, that in whatever part of the world, and at whatever height in the atmosphere, air is taken, it is found, when chemically examined, to contain azote and oxygen in exactly the same proportions.

Quantity of air required for Ventilation. If the question were solely how to command a sufficient supply of fresh air, it would be easily solved: but as in our climates the temperature of the external atmosphere is in winter generally very much lower than is necessary for comfort, we have at the same time to provide for the maintenance of an artificial temperature in our apartments, by allowing the air to enter no faster than it can be warmed. One of the first points, therefore, to be considered, is the amount of the supply of fresh air which an individual requires for comfort and health. This, however, is a point on which, by reason of the great variety of circumstances concerned, it is extremely difficult to arrive at any satisfactory conclusion.

Dr. Henry estimates that an adult person makes, on the average, 20 inspirations per minute, and draws into his lungs at each inspiration 20 cubic inches of air. Peclet allows 40 cubic inches for each inspiration. Taking the mean of the two estimates, we have 600 cubic inches expired per minute. But, according to Dr. Arnott, air expelled from the lungs is found to vitiate, so as to render unfit for respiration twelve times its own bulk of pure air; hence, the quantity of air spoiled every minute by the respiration of an adult, is 7200 cubic inches, or rather more than 4 cubic feet. Dr. Arnott, however, supposes the waste to be only half of this quantity. But there are several other causes of deterioration besides the production of carbonic acid from the lungs: the effluvia and vapor of animal matter exuded from the whole surface of the body is not less injurious than carbonic acid; and, according to M. Seguin, in a temperature of 60°, about 8¼ cubic feet of air per minute is charged with animal vapor transmitted through the skin of an adult, and rendered unfit for respiration. When artificial lights are used, a further allowance must be made for the waste by combustion. Besides, air is required for various other purposes than those which have now been mentioned. It acts as a cooling power, and hence the supply requisite for comfort depends on its temperature. It likewise serves to carry off moisture from the skin, and therefore its state as to dryness or humidity must be considered. Dr. D. B. Reid found, from observations on a number of persons assembled in an experimental room, that not less than 10 cubic feet per minute should be allowed to each individual on the average, at an agreeable temperature; but that, to maintain the atmosphere in all its purity, a much larger supply would at times be desirable. On the whole, therefore, we may conclude that 10 cubic feet of fresh air per minute, for each individual, is the smallest allowance that should be made in order to ensure healthful ventilation.

The experiments of Leblanc upon vitiated atmosphere are of high interest. The quantity of carbonic acid in the atmosphere in the normal state, has been shown by the Saussures to vary from 3 to 6 parts in 10,000. Leblanc (Ann. de Chim. v. 223) has examined the quantity in crowded rooms, theatres, cities, &c. In the hospital La Pitie, the air of one of the wards containing 54 patients afforded 8-1000 of carbonic acid gas, that is, 5 times more than that of normal air. Under similar circumstances, at the Salpetriere, the quantity was 8-1000. In Dumas's class room, after a lecture of an hour and a half, where 900 persons were present, the carbonic acid amounted to 1 per cent., and the same quantity of oxygen had disappeared. From other experiments, he considers this a maximum quantity for safety, and strongly recommends a better ventilation when so much carbonic acid is present. The result agrees with experiments made in this country. When the atmosphere is deteriorated by burning charcoal, he has seen death produced when 8 per cent. of carbonic acid was present in the atmosphere. In all such cases of death from stoves, he has found carbonic oxide in the air, and he attributes a deleterious effect to the agency of this gas. He has observed 1 per cent. of this gas to destroy an animal in two minutes, which is at variance with the statement of Nysten. This observation explains many of the inconsistencies which appeared some years ago in the evidence of some London chemists respecting the influence of Joyce's stoves. It is quite obvious that their structure was dangerous. Leblanc found that a candle was extinguished in air containing 4½ or 6 per cent. of carbonic acid. In such an atmosphere, life may be kept up for some time, but respiration is oppressive, and the animal is affected with very great uneasiness. Air expired from the lungs contains about 4 per cent. of carbonic acid, and hence this atmosphere is noxious. Even 8 per cent. in the atmosphere killed birds.

Dr. Chowne of London, has enrolled a patent, for improvement in ventilating rooms and apartments, for the perfect efficacy of which, we believe, there cannot be a doubt, and on a principle at once most simple and unexpected. The improvements are based upon an action in the syphon which had not previously attracted the notice of any experimenter, viz., that if fixed with legs of unequal length, the air rushes into the shorter leg, and circulates up, and discharges itself from the longer leg. It is easy to see how readily this can be applied to any chamber, in order to purify its atmosphere. Let the orifice of the shorter leg be disposed where it can receive the current, and lead it into the chimney (in mines, into the shafts), so as to convert that chimney or shaft into the longer leg, and you have at once the circulation complete. A similar air-syphon can be employed in ships, and the lowest holds where disease is generated in the close berths of the crowded seamen, be rendered as fresh as the upper decks. The curiosity of this discovery is, that air in a syphon reverses the action of water, or other liquid, which enters and descends, or moves down in the longer leg, and rises up in the shorter leg.

VERDIGRIS, or acetate of copper, is a preparation made by the cake, or marc of the wine-presses in the South of France. Thin plates of copper are exposed for some time to their action, and being coated with verdigris, the operation is finished by pressure into loaves of the substance.

VERDITER. A blue pigment, generally prepared by decomposing solution of nitrate of copper by the addition of chalk. It is a hydrated percarbonate of copper.

VERMICELLI, is a paste of wheat flour, drawn out and dried in slender cylinders, more or less tortuous, like worms, whence the Italian name. The *gruau* of the French is wheat coarsely ground, so as to free it from the husk; the hardest and whitest part, being separated by sifting, is preferred for making the finest bread. When this *gruau* is a little more ground, and the dust separated from it by the bolting-machine, the granular substance called *semoule* is obtained, which is the basis of the best pastes. The softest and purest water is said to be necessary for making the most plastic vermicelli dough; 12 pounds of it being usually added to 50 pounds of *semoule*. It is better to add more *semoule* to the water, than water to the *semoule*, in the act of kneading. The water should be hot, and the dough briskly worked while still warm. The Italians pile one piece of this dough upon another, and then tread it well with their feet for two or three minutes. They afterwards work it for two hours with a powerful rolling-pin, a bar of wood from 10 to 12 feet long, larger at the one end than the other, having a sharp cutting edge at the extremity, attached to the large kneading-trough.

When the dough is properly prepared, it is reduced to thin ribbons, cylinders, or tubes, to form vermicelli and macaroni of different kinds. This operation is performed by means of a powerful press. This is vertical, and the iron plate or follower carried by the end of the screw fits exactly into a cast-iron cylinder, called the *bell*, like a sausage-machine, of which the bottom is perforated with small holes, of the shape and size intended for the vermicelli. The *bell* being filled, and warmed with a charcoal fire to thin the dough into a paste, this is forced slowly through the holes, and is immediately cooled and dried by a fanner as it protrudes. When the threads or fillets have acquired the length of a foot, they are grasped by the hand, broken off, and twisted, while still flexible, into any desired shape upon a piece of paper.

The macaroni requires to be made of a less compact dough than the vermicelli. The former is forced through the perforated bottom, usually in fillets, which are afterwards formed into tubes by joining their edges together before they have had time to become dry. The *lazagnes* are macaroni left in the fillet or ribbon shape.

VERMILION, is Ethiop's mineral, heated red-hot, and sublimed. It is e bi-sulphuret of mercury. In a cake it is *cinnabar*, but, in powder, *vermilion*.

Chinese Vermilion.—Take quicksilver and sulphur, in the proportion of sixteen parts of the former, to four of the latter. After powdering the sulphur, place the two ingredients in an earthen jar, the outside of which, to exclude the air, must be plastered with mud and salt, to the thickness of three inches and a half; place an iron cover on the mouth of the jar, and let it be kept constantly moist. Place the jar in an oven, early in the morning, and at the same hour on the next morning extinguish the fire; at noon take it out of the oven, and, when cold, break the jar in pieces, and take out the contents. Pick out the dross, and then reduce the rest to a fine powder: let this be poured into a large jar full of water. After a time, a thin coating will be found on the surface of the water, which must be skimmed off, and a portion of the water let off; in a short time this process must be repeated, and the third time let all the water be drained off. The sediment is then exposed to dry, and taken out in cakes.

The humid process of Kirchoff has of late years been so much improved, as to furnish a vermilion quite equal in brilliancy to the Chinese. The following process has been recommended: Mercury is triturated for several hours with sulphur, in the cold, till a perfect ethiops is formed; potash ley is then added, and the trituration is continued for some time. The mixture is now heated in iron vessels, with constant stirring at first, but afterwards only from time to time. The temperature must be kept up as steadily as possible at 130° Fahr., adding fresh supplies of water as it evaporates. When the mixture which was black, becomes, at the end of some hours, brown-red, the greatest caution is requisite, to prevent the temperature from being raised above 114°, and to preserve the mixture quite liquid, while the compound of sulphur and mercury should always be pulverulent. The color becomes red, and brightens in its hue, often with surprising rapidity. When the tint is nearly fine, the process should be continued at a gentler heat, during some hours. Finally, the vermilion is to be elutriated, in order to separate any particles of running mercury. The three ingredients should be very pure. The proportion of product varies with the constituents. (*See* MERCURY.)

VIBRATION. Reciprocal motion. In music, that regular reciprocal motion of a body, which, suspended or stretched between two fixed points, swings or shakes to and fro. The vibrations of chords are the source of the different tones they emit. If two strings or chords of a musical instrument merely differ in length, their tones, that is, the number of vibrations they make in equal times, are in the reverse ratio of their lengths. If they differ in their diameters only, their sounds will be in the inverse ratio of their diameters. To measure the tension of strings, let us conceive them stretched by weights attached to their ends; then their sounds will be in the direct ratio of the square roots of the weights stretching them; that is, the pitch of a string stretched by a weight equal to 4 will be an octave above the pitch of a string stretched by a weight 1.

Vibration in mechanics is the reciprocating motion of a body, as of a pendulum, a musical chord, or elastic plate. The term *oscillation* is, however, more frequently used to denote a slow reciprocating motion, as that of the pendulum, which is produced by the action of gravity on the whole mass of the body; while *vibration* is generally confined to a motion with quick reciprocations, as that of a sonorous body, and which proceeds from the reciprocal action of the molecules of the body on each other when their state of equilibrium has been disturbed.

Metallic rods or glass tubes may vibrate longitudinally like stretched chords. In this case they divide themselves spontaneously into several parts, which vibrate in unison; and are separated by *nodes*, or

parts which remain at rest. The extreme parts are shorter than the others, which are all of equal length ; but the vibrations of all the parts are synchronous. This sort of vibration may be induced in a slip or tube of glass, by holding it between the fingers, in the middle, and rubbing it longitudinally with a piece of moist cloth, when it will emit a very acute sound.

Vibrations of Elastic Plates.—All elastic solid bodies, when put into a state of vibration, may be conceived, in reference to the internal motions of their molecules, as spontaneously separating themselves into parts, each of which vibrates independently of the others, and in such a manner that the molecules of one part are at every instant moving in a direction opposite to that of the molecules of the adjacent part. It follows that the points of separation between two parts participate neither in the motion of the one nor of the other, and consequently remain at rest. In the case of thin elastic plates, the continuity of these points forms lines of repose, or *nodal lines*, the forms and positions of which are detected by placing the vibrating plate in a horizontal position, and strewing a small quantity of fine sand over its upper surface. This ingenious mode of determining the nodal lines was pointed out by Galileo in his *Dialogues*, and was practised by Chladni (*Traité d'Acoustique*) and more recently by Savart in his numerous experiments on this subject.

These lines assume a great variety of forms, depending on the figure of the plate, the position of the point or points at which it is fixed, and the rapidity and direction of the motion by which the vibration is communicated to it. Circular plates afford numerous different systems of nodal lines. When the plate is fixed at its centre between two knobs or points held fast by a vice, two nodal lines are in general produced, crossing each other at the centre. By applying the finger to the plate at a suitable point, so as to interrupt the vibration, three of those lines may be formed. Disks of metal furnish a number of nodal lines, dividing the circle into numerous sectors. In certain circumstances these straight nodal lines are intersected by a greater or smaller number of concentric circular lines; the circular lines may also exist by themselves; and sometimes the nodal lines assume the form of the branches of a hyperbola.

VICE, used by smiths, is a common instrument with two cheeks, made to hold or bite by a screw of power.

The vice for glaziers is one by which prepared lengths of lead are drawn through it in slips for windows, the hole or tool being the form of the slips, and the force applied by a winch handle.

VINEGAR. Under the head ACETIC ACID is given the mode of making vinegar from alcohol. Under the present head will be noticed the manufacture from fermenting vegetable juices. Almost all the vinegar of this country is made from cider. It is only lately, however, that any regularity or care in the manufacture was exhibited.

The old mode was to put out cider or water and molasses in a cask, exposed to the sun, until it became fully fermented. (*See* FERMENTATION.)

The oxygen of the atmosphere, although it is not now, as was once believed to be, the only acidifier, still it is the great one, and vinegar is formed by the cider parting with carbonic acid gas which it cannot do without absorbing oxygen. The reasonable way, then, to make vinegar rapidly and surely, is to expose the cider as much as possible to the atmosphere. The new way, and what is supposed by many, incorrectly, to be a patent way to make vinegar, is to let the cider percolate over a very exposed surface. The apartment where it is made is freely exposed to the air, and is kept at a temperature of above 60°. The cider is left to run in small streams into troughs with bottoms full of small holes, then from that over very fine wood shavings, such as soft maple, and let these be fully exposed to the air and resting on a slatted bottom made of clean bows or laths, below which the vessel for receiving it should be placed; vinegar can be made from molasses and water, grapes, corn stalks, beet roots, and many other substances, by this process in a few days. Cider, however, makes the best vinegar. Many modifications (for cheapness) of the above plan may be resorted to, the grand secret being the exposure of the liquids to be changed into vinegar in layers or strata to the oxygen of the atmosphere.

The following is the plan of making vinegar at present practised in Paris. The wine destined for vinegar is mixed in a large tun with a quantity of wine lees, and the whole being put into sacks, placed between the plates of a press, the liquid matter is pressed out.

What passes through is put into large

casks, set upright, having a small aperture in their top. In these it is exposed to the heat of the sun in summer, or to the heat of a stove in winter.

Fermentation comes on in a few days. If the heat should then rise too high, it is lowered by cool air, and the addition of fresh wine. In summer the process is generally completed in a fortnight; in winter double the time is requisite. The vinegar is then run off into barrels, which contain several chips of beech wood to clarify it: in about a fortnight it is fit for sale.

Almost all the vinegar of the north of France being prepared at Orleans, the manufactory of that place has acquired such celebrity as to render their process worthy of a separate consideration.

The Orleans casks formerly contained nearly 200 gallons of wine, but at present only about half that quantity. Those which have been already used are preferred. They are placed in three rows one over another, and in the top have an opening of two inches diameter, which has a bung fitting close; there is another spill hole on the side to admit the air. Wine a year old is preferred for making vinegar, and is kept in adjoining casks, containing beech shavings, to which the lees adhere.

The vinegar from sugar is made as follows:—Ten pounds of sugar are added to eight gallons of water, with yeast and raisins or grape cuttings, to assist in the fermentation; twelve pints of bruised gooseberries, or other fruits, are added; and, by a process similar to that for cider, good vinegar is soon produced.

By distillation the coloring matter in mucilage is separated; but the fragrant odor is generally replaced by an empyreumatic one.

The specific gravity varies from 1·005 to 1·015.

The *Vinegar of Wood*, as it comes over in the first distillation, with its tar and empyreumatic oils, is extensively used in preserving meat and all animal substances. A single dipping, or washing, destroys all tendency to putrescence and decomposition, and operates like its smoke, in curing hams, fish, &c. This property is due to the presence of creosote.

It is also found to be highly efficacious in checking putrescence in wounds and ulcers, and in arresting scrofula, and obstinate local inflammations.

It is prepared by the destructive distillation of any kind of wood. It is then re-distilled in a copper still, leaving one-fifth residuum of tough, tarry matter. The product, brown vinegar, is then distilled a third time, and absorbed by lime, dried, and torrified as calcareous salt. This is decomposed by sulphuric acid, and the product is pure acetic acid. At 75°, one part with 11 of water is the common distilled vinegar of medicine.

Pyroligneous acid is prepared, quite colorless, by distillation from the acetate of lime above mentioned, is of sp. gr. 1·063, and is seven times stronger than table, or pickling vinegar, and requires seven volumes of water for culinary purposes. A piece of meat, or a whole animal dipped in it, or sponged, or brushed with it, remains sweet and free from putrescence for months or years.

Four-thieves Vinegar.—In two pints of strong acetic acid, for 7 days, digest 1 oz. of rosemary-tips and of sage-leaves, ½ an oz. of lavender-naps, and 1 scruple of cloves; (some add half a clove of garlic.) Press well, and filter.

VIOLET DYE, is produced by a mixture of red and blue coloring-matters, which are applied in succession. Silk is dyed a fugitive violet with either archil or Brazil wood; but a fine fast violet, first by a crimson with cochineal, without tartar or tin mordant, and after washing, it is dipped in the indigo vat. A finish is sometimes given with archil. A violet is also given to silk, by passing it through a solution of verdigris, then through a bath of logwood, and, lastly, through alum water. A more beautiful violet may be communicated by passing the alumed silk through a bath of Brazil wood, and after washing it in the river, through a bath of archil.

To produce violets on printed calicoes, a dilute acetate of iron is the mordant, and the dye is madder. The mordanted goods should be well dunged.

VITRIOL, WHITE, is composed of sulphuric acid and oxide of zinc.

White vitriol, or sulphate of zinc, is composed of 40 parts of sulphuric acid, and 41 parts of zinc, also in the state of oxide. (*See* ZINC.)

Blue Vitriol is the sulphate of copper, obtained simply by evaporating the waste water of mines; or, sometimes, by roasting copper pyrites. In other cases the sulphate is converted into copper, by immersing iron in the water, and then treated with sulphuric acid. It is often used as an emetic, and applied to indolent ulcers, and as a collyrium.

Green Vitriol, or *Copperas*, is protosulphate of iron, made by exposing iron pyrites to air and water. It is then digested with iron turnings, to get rid of the excess of sulphuric acid. (*See* COPPERAS.)

VOLTAIC ELECTRICITY. The phenomena resulting from the evolution of electricity by chemical action, as manifested by that important instrument of electro-chemical research called the *Voltaic Battery*, are usually included under the above term. Whenever substances act chemically upon each other, their electrical states are disturbed; but the electricity thus evolved is, in ordinary cases, so lost and dissipated as to escape observation. It may, however, be rendered manifest by the following simple arrangements: When a plate of pure zinc (or of common zinc rubbed over or amalgamated with mercury) is dipped into a glass of very dilute sulphuric acid, little or no action is observed; nor does any thing happen when a similar plate of silver is placed in the same cup of acid, provided the metals be kept apart from each other. But if the zinc and silver be brought into contact, at their extremities out of the liquid, the water is decomposed; its oxygen combines with the zinc to form oxide of zinc, which is dissolved by the acid; and its hydrogen passes over to the surface of the silver, where it collects, and ultimately escapes in gaseous globules. These phenomena are further connected with the production of a continuous current of electricity passing *from* the zinc across the water *to* the silver, and again from the silver, by metallic contact, to the zinc, in the direction of the wire or connection. It is not necessary that the metals should be connected exactly by juxtaposition; but it *is* necessary to the establishment of the continuous electric current that they should be somewhere in contact, or at least connected by what is usually termed a perfect conductor. By modifying the preceding arrangement, so that the metallic contact between the plates be made *out* of the vessel, the electric current takes the same direction, travelling through the liquid *from* the zinc or generating plate *to* the conducting plate, and through the wires back again to the zinc. Here again the zinc is oxidized and dissolved, and hydrogen is liberated upon the silver plate; but the moment that the circuit is broken, by parting the wires, these actions cease, because the electric current ceases to flow. It is evident that various substances may be interposed between the wires, or they may be immersed into different liquids; and provided these are capable of transmitting electricity, the current will still pass, and its phenomena under a variety of circumstances may be studied. In this arrangement the end of the wire from the silver plate is the *emitting*, and of that from the zinc the *receiving* point or pole; hence these have been termed, in reference to the common electrical machine, the *positive* and *negative poles*. Mr. Faraday, with a view of avoiding certain misapprehensions to which these terms give rise, calls them the *electrodes;* the posiitve electrode he further terms the *anelectrode*, and the negative the *catelectrode*, or anode and kathode.

In the preceding paragraph it has been assumed that the generating metal is *zinc*, the conducting or conveying metal *silver*, and that the intermediate liquid is *dilute sulphuric acid.* A number of other metals may be substituted for the above; namely, for the zinc, cadmium for instance, or iron; and for the silver, platinum, gold, or copper. Many liquids may also be substituted for the dilute sulphuric acid; the requisite condition being that one of the metals shall be chemically acted on, whilst the other is indifferent, or at least not acted on by the liquid to the same extent. And the current is always in the direction above represented; that is to say, passes *from* the metal most attacked *to* that least attacked, whenever the communication is perfect or the circle closed. In the above cases also certain forms of charcoal, which are excellent conductors of electricity, may be substituted for the conveying metal, or passive element of the arrangement. Another requisite condition to the phenomena properly called *Voltaic* is that the interposed fluid shall conduct: and further, that it shall be capable of that form of decomposition which Faraday has designated *electrolysis*, that is, resolvable into its elements by the electric current.

The *quantity* of electricity generated in the above instances depends chiefly upon the superficial extent of the metals concerned, and upon the activity of the liquid acting upon the generating metal; and that it is considerable, even where small surfaces and weak acids are used, is manifest by the violence with which the magnetic needle of the galvanometer is deflected. But in the above described arrangements, the *intensity* of the electricity is very feeble; and in order to attain this, and to give the current that apparent impetus which it requires to traverse bad conductors, and easily to effect electro-chemical decompositions, it becomes necessary to repeat the metallic alternations; or, in other words, to employ a properly arranged succession of generating, conducting, and electrolytic substances. This leads to the grand discovery of Volta; namely, the construction of the *Voltaic Pile* or *Battery*.

In this arrangement, which, like the simple circles, admits of infinite varieties, the metals generally used are zinc on the one hand, and copper or silver or platinum on the other. The alternation originally adopted by Volta, and which are quite effectual, were zinc, silver, and flannel or pasteboard soaked in acid; and these were repeated according to the effects that were to be obtained. The inconvenience of arrangement led him, however, to various modifications of it; and, among them, to the use of a series of separate vessels, which he called the *crown of cups* (conronne des tasses,) and which, slightly modified, has since been very generally adopted. The flannel is rejected, and in its place a cup of dilute acid, or other proper electrolyte, is substituted; so that each silver and zinc plate are in metallic communication, though in separate vessels: the arrangement being zinc, acid, silver; zinc, acid, silver, &c. Here the direction of the electric current is the same as in the simple circle, namely, from the zinc through the liquid to the silver; but in this form of the apparatus, for the mere convenience of carrying on the series, the conducting wire connected with the first zinc plate has a supernumerary silver one attached to it, and that with the last silver plate a supernumerary zinc plate; so that much confusion has arisen in regard to the direction of the current in these cases, in consequence of calling what is here the silver extreme the *negative pole*, and the zinc extreme the *positive pole*; whereas it is in fact the reverse, and the circulation of the current goes on through the electrodes precisely as in the simple circle. But though the *direction* of the current is the same, and the absolute *quantity* of travelling or circulating electricity not increased, the case as regards *intensity* is very different; and with numerous series arranged as above we obtain, on removing the electrodes (which in this experiment ought to consist of pointed pieces of well-burned boxwood charcoal) a little from each other, a most brilliant and continuous current of fire, luminous, so that the eye can scarcely endure it, and capable of overcoming obstacles and traversing conductors and electrolytes in a way essentially different from that of the simple circuit. Yet, even with all these energetic phenomena, and with a quantity of circulating electricity far beyond any thing which the most powerful frictional machines can afford, the intensity is still insufficient to penetrate a thin layer of card or paper, or to make its way through non-conducting obstacles, as it does in the case of the discharge of the Leyden jar or battery. And now, if the hands be well moistened with salt and water, so as to overcome the non-conducting tendency of the cuticle, and the body be made part of the circuit, an extraordinary and unendurable sensation is perceived, which is in fact a *continuous shock*. By the same means wires may be ignited, metals burned, combustibles exploded, magnets made, and galvanometers affected at any distance from the pile, provided the conducting communication is perfect. Thus it is that this power has been used to blast rocks, to explode gunpowder under water, and to communicate telegraphic signs, as in the arrangement of Professors Morse & Wheatstone, Messrs. Bain, House, &c.

But the most important modification of this instrument is that suggested by Mr. Daniell, and which he terms "a constant battery." In all the preceding arrangements the electrical power is liable to fluctuation; and after a time various causes induce such a falling off of its evolution as to render them inconvenient, or even useless, where continuous or regular action is required. In Wollaston's battery, for instance, which is the best of them, several circumstances combine to render it inconstant in its action: the adhesion of hydrogen to the copper plate, and the precipitation of zinc upon it, the saturation of the acid by oxide of zinc, and the local action which common zinc induces, are perhaps the principal sources of the above-mentioned irregularity and inconstancy. In Mr. Daniell's arrangement those inconveniences are to a great extent obviated; and although it is more complicated than the preceding, its constant and regular action, when it is properly constructed, amply repays the additional trouble and expense: there are, indeed, many investigations which can scarcely be carried on without it. (*See* ELECTRO METALLURGY, for a view of Daniell's battery.)

Under the articles ELECTRO METALLUR-

OGY and TELEGRAPH are found descriptions of Voltaic batteries.

Not only are the ultimate elements of binary compounds evolved in obedience to certain uniform laws, but *proximate* elements are also similarly separated. Thus, when sulphate of soda, nitrate of potassa, and other neutral salts, are subjected in aqueous solution to the action of the current, the respective acids travel with the oxygen to the anode, and the alkalies, oxides, or bases, with the hydrogen to the cathode. Faraday terms substances susceptible of these transferences *ions*, and those which go to the anode *anions;* those to the cathode *cations:* thus doing away with the less definite terms of *electro-negative* and *electro-positive* bodies.

WAINSCOT. In architecture, the framed lining in panels wherewith a wall is faced. The wood originally used for this purpose being a species of foreign oak, that wood has acquired the name from the purpose to which it was thus applied.

WAIST. That part of the gun-deck between the fore and main masts.

WATCH. A well-known portable machine, moved by a spring, for measuring time. When executed in the most perfect manner, it is called a *chronometer*, and used in navigation for determining differences of longitude.

Watches are said to have been made at Nuremberg so early as 1477; but it is uncertain how far the watches then constructed resembled those which now go by that name. Some of the early ones were very small, in the shape of a pear, and sometimes sunk or fitted into the top of a walking-stick. As time-keepers, watches could have very little value before the application of the spiral spring as a regulator to the balance. The merit of this excellent invention has been claimed by Hooke and Huygens; but it seems established by unquestionable evidence that the priority belonged to Hooke by at least fifteen years. The date of the invention is about 1658. Hooke's first balance spring was straight, and acted on the balance in a very imperfect manner; but he soon perceived its defects, and attempted to obviate them by adopting first the cylindrical, and afterwards the flat spiral. The latter appears to have been applied to watches before the publication of Huygens' claim in 1675.

WATCH-MAKING. The wheels in spring-clocks, and in watches, are urged on by the force of a spiral spring, contained in a hollow cylindrical barrel, or box, to which one end of a cord or chain is fixed, and lapping it round the barrel, for several turns outside: the other end is fixed to the bottom of a solid, shaped like the frustrum of a cone, known by the name of the *fusee*, having a spiral groove cut on it: on the bottom of this cone, or fusee, the first or great wheel is put. (*See* FUSEE.)

The arbor, on which the spring-barrel turns, is so fixed in the frame that it cannot turn when the fusee is winding up: the inner end of the spring hooks on to the barrel arbor, and the outer end hooks to the inside of the barrel. Now, if the fusee is turned round in the proper direction, it will take on the cord or chain, and, consequently, take it off from the barrel. This bends up the spring; and, if the fusee and great wheel are left to themselves, the force exerted by the spring in the barrel, to unbend itself, will make the barrel turn in a contrary direction to that by which it was bent up. This force of the spring unbending itself, being communicated to the wheels, will set them in motion, and they will move with considerable velocity.

Their time of continuing in motion will depend on the number of turns of the spiral groove on the fusee, the number of teeth in the first or great wheel, and on the number of leaves in the pinion upon which the great wheel acts, &c.

The wheels, in any sort of movement, when at liberty, or free to turn, and when impelled by a force, whether it is that of a weight or of a spring, would soon allow this force to terminate; for, as the action of the force is constant from its first commencement, the wheels would be greatly accelerated in their course, and it would be an improper machine to register time or its parts. The necessity of checking this acceleration, and making the wheels move with a uniform motion, gave rise to the invention of the *escapement*, or '*scapement*, as it is commonly called. To effect this, an alternate motion was necessary, which required no small effort of human ingenuity to produce.

The *escapement* is that part of a clock or watch, connected with the beats which we hear it give; and these beats are the effects of the moving power, carried forward by means of the wheels in the movement to the last one, which is call ed the *swing-wheel* in a pendulum clock, and the *balance-wheel* in a watch.

The teeth of this wheel act on the pallets or verge, which are of various shapes, and which form the most essential part in a scapement; they drop from each tooth of the swing or balance-wheels, on their respective pallets, giving one beat or impulse to the pendulum or balance, in order to keep up or maintain their motion; and, were it not for the pallets, which alternately stop the teeth of the swing or balance-wheels, the motive-force would have no check.

Hence it is, that, by this mechanism of the 'scapement, the wheels in the movement are prevented from having their revolutions accelerated.

WATER CLOCK. A contrivance for measuring time by the flow of water.

WATER GAS. This name is applied to the compound gases derived from the decomposition of resin and the admixture of hydrogen from decomposition of water. So long back as 1833, Mr. Jobard, in France, produced hydrogen by the decomposition of water, and applied it to the purposes of illumination with great success. He obtained his hydrogen by the decomposition of steam in vertical retorts, filled with incandescent coke, and unites the gas just as it is formed with bicarburetted hydrogen produced by the distillation of any hydro-carburet, as oil, tar, naphthaline, and other products at present rejected in ordinary gas works.

In 1848, Mr. S. White patented in England an apparatus for the manufacture of gas from water and common tar, or resin, &c. The apparatus consisted of three retorts, placed on a stove, two of which are filled with charcoal, and thin pieces of iron, and the other with iron chains, hanging from a centre bar. The first two retorts are for the decomposition of water, which is regularly supplied by a syphon pipe, passing through and into the centre of the retort. The water in passing through the heated material becomes converted into pure hydrogen. It then passes into the third retort, to receive its full dose of bicarburet of hydrogen, which is prepared from common tar, resin, or similar substances, passing or dropping on the red-hot chain from a syphon tub, which regulates its supply. This causes the tar or melted resin to throw off olefiant gas in abundance. The mixed gases are then conveyed into the gasometer without purification, none being required. Its great advantages are that it only requires an apparatus, which may be small, simple, and cheap; and the beautiful light produced is superior to the ordinary coal-gas. It may be manufactured on small concerns, as manufactories, hotels, and large mansions; and may be burned in any room without any unpleasant smell being evident.

WATER MEADOWS. Meadows on low flat grounds, capable of being kept in a state of fertility by being overflown with water from some adjoining river or stream. The principal season at which this operation is performed is during winter, when the water is allowed to remain stagnant on the surface for some weeks; but meadows which can be watered are occasionally overflown during summer, especially after a crop of hay has been taken. The manner in which water so applied to grass lands is found beneficial has never been satisfactorily explained. By some it is attributed to the warmth retained in, or communicated to, the soil, by the water during winter; by others to its effect in destroying insects, worms, &c.; and by some to the particles of manure deposited on the surface of the soil. During summer the effect is more readily accounted for, a supply of moisture being advantageous to all plants at that dry season. (*See* IRRIGATION.)

WATER OF CRYSTALLIZATION. Some crystallized salts contain more or less water, which, as it bears a definite proportion to the other components of the salt, may be considered as one of its essential constituents. Crystallized sulphate of lime, for instance, is a compound of 68 of dry sulphate and 18 water, or of 1 equivalent of anhydrous salt and 2 equivalents of water; 1 equivalent of crystallized sulphate of magnesia=123, contains 7 of water = 63; and an equivalent of crystallized sulphate of soda=162, contains 10 of water=90; the equivalent of water being 9. But it does not necessarily follow that a salt in crystals contains water, there being many crystals which are *anhydrous*, such as nitre, sulphate of potash, &c.

WATER TABLE. In architecture, a projection or horizontal set-off in a wall, so placed as to throw off the water from the building.

WATER WAYS. Strong pieces of wood extending round the ship, at the junction of the decks with the sides, to carry off the water.

WATER WHEEL. In hydraulics, an engine for raising water in large quan-

tities. Also a wheel turned by the force of running water. Of these there are two kinds: the ***undershot wheel***, and the ***overshot wheel***.

The force on an overshot water-wheel is that of the weight of the water falling on it, the power being to the effect as three to two. The force on an undershot-wheel is the velocity of the body of water, the power being to the effect as three to one, or half the other.

The particles of fluids are found to flow over or amongst each other with less friction than over solid substances; and as each particle has weight, it follows that no quantity of homogeneous fluid can be in a state of rest, unless every part of its surface is on a level. As the particles of all liquids are heavy, any vessel containing a liquid will be carried towards the earth by the twofold motion, with a power equivalent to the weight it contains, and, if the quantity of the fluid be doubled, tripled, &c., the influence will be doubled, tripled, &c.

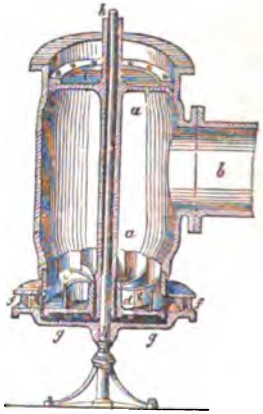
The pressure of fluids is, therefore, simply as their heights—a circumstance of great importance in the construction of pumps and engines for raising water. As atoms of liquids fall independently, if a hole be made in the bottom of the vessel the liquid will flow out, those particles directly over the hole being discharged first. Their motion causes a momentary vacuum, into which the particles tend to flow from all directions, and thus the whole mass of the water, and not merely the perpendicular column above the orifice, is set in motion.

When water flows in a current, as in rivers, it is in consequence of the inclination of the channel, and its motion is referable to that of solids descending an inclined plane; but, from want of cohesion among its particles, the motions are more irregular than those of solids, and involve difficult questions. The friction between a solid and the surface on which it moves can be accurately ascertained; but this is not the case with liquids, one part of which may be moving rapidly and another slowly, while another is stationary.

In rivers and pipes, the water in the centre moves with greater rapidity than at the rubbing sides, so that a pipe does not discharge as much water in a given time, in proportion to its magnitude, as theoretical calculations would lead us to suppose. As water, in descending, follows the same laws as other falling bodies, its motion is accelerated; in rivers, therefore, the velocity and quantity discharged at different depths would be as the square roots of those depths, did not the friction against the bottom check the rapidity of the flow.

The same law applies to the spouting of water through jets or adjutages.

One of the most useful forms of water, which is that of French invention, called the *turbine*, is a species of hydraulic engine, employed to a considerable extent in modern times, as a prime mover for machinery. It is considered to be preferable to ordinary water-wheels, in situations where the height of the fall is great and the quantity of water not very considerable. The annexed cut represents an example of a turbine, or *horizontal water-wheel.* The water is introduced into a close cast-iron vessel *a*, by the pipe *b*, connecting it with the reservoir. Here, by virtue of its pressure, it tends to escape by any aperture which may be presented; but the only apertures consist of a series of curved float boards *f f*, fixed to a horizontal plate *g*, mounted upon a central axis *h*, which passes upwards through a tube connecting the upper and lower covers, *c* and *d*, of the vessel *a*. Another series of curved plates *e e*, is fixed to the upper surface of the disk *d*, to give a determinate direction to the water before flowing out at the float boards, and the curves of these various parts are so adjusted as to



render the reactive force of the water available to the utmost extent in producing a circular motion. The machinery to be impelled is connected with the axis *h*.

WATER-PROOF CLOTH. (*See* CAOUTCHOUC.)

A patent was obtained, in 1830, by Mr. Thomas Hancock, for rendering textile fabrics impervious to water and air, by spreading the liquid juice of the caoutchouc tree upon the surfaces of the goods, and then exposing them to the air to dry. It does not appear that this project has been realized in our manufactures.

Mr. William S. Potter proposes, in his patent of 1835, to render fabrics waterproof by imbuing them with a solution of isinglass, alum, and soap, by means of a brush applied to the wrong side of the cloth, distended upon a table. After it is dry, it must be brushed on the wrong side, against the grain. Then the brush is to be dipped in clean water, and passed lightly over the cloth. The gloss caused by the above application can be taken off by brushing the goods when they are dry. Cloth so prepared is said to be impervious to water, but not to air.

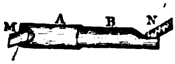
Mr. Sievier's plan of rendering cloth water-proof, for which he obtained a patent in 1835, consists in spreading over it, with a brush, a solution of India-rubber in spirits of turpentine, at one or more applications, and then applying a similar solution mixed with acetate of lead, litharge, sulphate of zinc, gum mastic, or other drying material. He next takes wool, or other textile material, cut into proper lengths, and spreads it upon the surface of the fabric varnished in this manner, for the purpose of forming the nap or pile. He then presses the cloth by means of rollers, or brushes, so as to fix the nap firmly to its surface.

WAVES. Undulations of fluids produced by displacements of the particles at some distance, and the subsequent effort of these to regain their equilibrium, or place themselves upon the same fluid level. The waves of the ocean produced by the action of the winds never attain the height which it is commonly estimated they do. Dr. Scoresby, in his estimation of the waves of the Atlantic Ocean, found the *average wave* to be 15 feet above the level of the water, supposing it to be a smooth plane; and the mean highest waves, not including the broken or acuminated crests, to be 43 feet above the hollow, or trough of the sea, produced by the walling up of the wave. It is only the upper stratum of the water which is thus agitated (from 15 to 20 feet from the surface), and the wave is not carried forward, but rises up and down, and thus displaces a fresh body of water in advance, compelling it to rise up, and become a wave in turn.

There are waves in the atmosphere as well as in the ocean, and the upper regions of the air have their currents, tides, and waves, just as the oceans of water. It is the elevation and depression of these great atmospheric waves which produce a corresponding movement in the mercury of the barometer tube.

This physical phenomenon of undulation is not confined to fluids and gases: it appears to be a property of the ether which fills space, agitations of which produce such interesting effects. Heat and electricity, it is presumed, are particular forms of undulation of the ether, and light is now generally admitted to be waves of ether; the nature and color of the light being produced by varieties in the undulation. To produce an ordinary ray of white light, it is not merely necessary that the ether should be agitated by horizontal waves, like those of the ocean, but that it should also have waves vibrating vertically, or from side to side: and these two kinds of waves are bound together in the ordinary ray of sunlight. These two rays may be separated by passing the sunlight through certain substances, as a clear crystal of Iceland spar, doubly refracting spar, a variety of carbonate of lime. By turning the crystal round in the hand above any object, such as a single letter on a white surface, two images of this letter will be perceived, one of which remains stationary, or nearly so, while the other travels round it in a circle; the latter is called the *extraordinary*, the former the *ordinary ray*. The phenomenon is produced by the refractive power of the spar, which thus resolves the luminous undulations into two colorless series at right angles to each other; when combined, constituting common light, and when separated, producing *polarized light*, so called, because they assume new and peculiar properties with regard to each other, and different refracting or reflecting media.

Many minerals polarize light, as agates and tourmalines. Light thus altered may also be obtained by reflection from surfaces, such as glass; and it was from this source it was first discovered by Malus. By more complicated methods, the ray of colorless light may be so much refracted as to be broken up into its colored rays, and then acting in a manner similar to the colorless ray, produces the phenomenon of *colored polarization*. This subject cannot be entered into minutely in this treatise. Polarized light is now made use of in the arts as a test for the purity of substances. It is found that liquids have the property of polarizing light similar to crystals, and not only is the amount of *separation* of the two rays constant at all times for the same substance, but even the *direction* is also permanent and unvarying; thus some substances turn the polarized ray to the right, and others to the left. It is only necessary, therefore, to know what the amount and direction of the deviation of the ray is, and then by looking into the tables made for that purpose, the exact substance will be found opposite to the figures in the table. Solutions of sugar, camphor, and many other organic liquids, naturally develop the phenomenon of *circular polarization*,—that is, make the ray revolve round. Oil of turpentine makes the ray rotate to the right; so also does naphtha and oil of anise, syrup of grape sugar and grape juice; while oils of citron and bergamot, solution of cane sugar, and tartaric acid, make the ray rotate to the left. Polarization is often made a useful test of the presence and purity of essential oils and volatile liquids. The instrument with which these experiments are made is called a polariscope; an illustration of which is given. It consists of a tube of brass one inch broad, and eight inches long, A, B, into which the fluid to be examined is placed. The tube is closed at the lower end by a plate of glass. At one extremity of this tube is placed a bundle of plates of window-glass N′ fixed so as to admit of ready motion, and supported by a screw in its place. These plates of glass receive the ray of light, polarize it, and transmit it through the tube containing the liquid. At the other end of the tube is placed the eye-piece M, consisting of a single image prism, or Nicholl's prism, which is a crystal of refracting spar sawed down the middle, and soldered together by Canada balsam. A bundle of thin glass plates may be used instead of this, if they are capable of being placed at any azimuth.



WAX. This is a common vegetable product forming the varnish which coats the leaves of certain plants and trees. It is also found upon some berries, as of the *Myrica cerifera;* and it is an ingredient of the pollen of flowers. It was long supposed that bees merely collected the wax thus ready formed in plants; but Huber found that though excluded from all food except sugar, they still formed wax; and accordingly it has been found that the elementary composition of bees' wax and vegetable wax is slightly different. Bees' wax is prepared by draining and washing the honeycomb, which is then melted in boiling water, strained, and cast into cakes. English and foreign wax are found in the market; the latter being chiefly imported from the Baltic, the Levant, and the coast of Barbary. Fresh wax has a peculiar honey-like odor: its specific gravity is ·96. At about 150° it fuses, and at a high temperature volatilizes, and burns with a bright white flame. It is bleached by being exposed in thin slices or ribbons to light, air, and moisture, or more rapidly by the action of chlorine; but in the latter case it does not answer for the manufacture of candles, which is one of its principal applications. Wax candles are made by suspending the wicks upon a hoop over the caldron of melted wax, which is successively poured over them from a ladle till they have acquired the proper size, so that the candle consists of a series of layers of wax; the upper end is then shaped, and the lower cut off. Attempts have been made to cast wax candles in moulds, but when thus made they burn irregularly. Bleached or white wax is generally adulterated with more or less spermaceti, and sold at different prices accordingly; in this case it has not the peculiar lustre of pure wax, and is softer and more fusible. It is also largely adulterated with stearine or stearic acid, which is detected by the odor or fat of tallow which it evolves when highly heated, and by its crumbly texture; it may also be separated to a certain extent by ether or alcohol. Wax is insoluble in water, and scarcely acted upon by the acids, so that it forms a good lute or cement: boiling alcohol and ether act partially upon it, and deposit the portion which they had dissolved, on cooling. Some varieties of vegetable wax appear to contain two distinct principles, which Dr. John has termed *cerin* and *myricin*; the former soluble, and the latter insoluble, in alcohol. Heated with the fixed alkalies, wax forms a difficultly soluble soap.

WEATHER-BOARDING. In architecture, feather-edged boarding nailed upright, whose boards lap over each other, so as to prevent the rain, &c., from penetrating them.

WEATHER GLASS. A name commonly given to the barometer; but sometimes also applied to other instruments for ascertaining the state of the atmosphere, or measuring atmospheric changes. It is thus applied to the *thermometer*, the *hygrometer*, &c.

WEAVING. The art of forming cloth in a loom by the union or intertexture of threads. The art of weaving is of great antiquity: it has been practised in all ages and in all countries; but it would be impossible within our limits to give even a sketch of its history, progress, and successive improvements down to its present perfect state. We had intended to present the reader with a sketch of the various improvements that have been made in the loom from its simplest construction, down to the elaborate invention of Jacquard; but it was found that this could not be effected without the introduction of numerous diagrams and details, which would have been foreign to the purpose of the work.

Spinning, or converting fibrous materials into threads for weaving, is one of the most important and extensive employments. The distaff was the first machine, and the thumb and finger the tools, with saliva for cement. These operations have, however, been imitated, 1st, by Hargreave, in his jenny, which drew out and twisted a dozen threads; 2d, by Arkwright, with his rollers of different velocity, in which he exactly imitated the action of the thumb and finger; and 3d, by Crompton, in his mules, by which he spins from 100 to 1000 threads. The same machinery is extended to cotton, flax, wool, silk, &c., and competition has raised factories, which, in bulk, are wonders of the world, by which the labor of twenty or thirty women at the distaff is now performed, in general better, by single children. Patents out of number have been taken, to improve, simplify, cheapen, and accelerate. These apply, however, to the finer fibres; but Long has recently applied the same principles to coarse hemp, by larger and stronger machinery.

The hemp is distributed on the endless leather of a spreading-table, by which it is conveyed to the feeding rollers, and by them delivered upon the gill, or needles, by the operation of which the fibres are drawn out and laid lengthways into a band of hemp of uniform width and thickness. The gill consists of a series of arms, projecting from an endless band, passing about two rollers, with indentations so arranged, that the ends of the arms next the chain fall successively into them, and cause the points or needles, projecting from other ends of the arms, to penetrate into the hemp, and to draw it out from the feeding rollers: and, when the needles have drawn the hemp, and carried it the length of the gill, they are withdrawn by their passing over the second notched roller, while the hemp is delivered to the pressing roller. The difference between this and the common flax gill consists in an adjustment, by which the distance between the feeding-rollers and the gill, as well as the extent of the drawing operation of the gill, can be regulated to correspond with the length of fibres to be operated upon. Another improvement is, the introduction, at pleasure, of an additional pair of drawing-rollers, with an adjustable gearing to give them motion, when the length of the fibre requires such an addition.

The other parts of the process of spinning cords for rope-makers do not differ materially from the usual operation of spinning flax, except the introduction of a series of folds of strong felt, through which the strand is drawn after it passes the conical condensing tube; the intention of which is to press down and cause to be mixed into the strand the ends of the fibres.

After all, the distaff-spinning of the Hindoo exceeds in fineness any product of machinery, and their shawls, silks, and muslins are miracles of human art.

WEDGE, in mechanics, is one of the five simple engines or mechanical powers, and is used sometimes for raising bodies, but more frequently for dividing or splitting them. In the former case, if we suppose the wedge to be urged by pressure, the action of the wedge is precisely the same as that of the inclined plane; for it is evidently the same, in point of mechanical advantage, whether the wedge be pushed under the load, or the load be drawn over the plane. The power is therefore to the force to be overcome as the tangent of the angle of the penetrating sides to the radius, leaving the friction out of consideration: hence the thinner the wedge the greater is its effect. But when the wedge, as is generally the case, is driven forward by percussion, its power cannot be estimated with any degree of accuracy. The percussive tremor excited by the blow destroys for an instant the friction at the sides, and augments prodigiously the penetrating effect. Besides, when the wedge is used in rending wood or other substances, the parts of the block are generally separated to a considerable distance before the edge of the wedge; in which case it acts besides as a lever, the power being applied at the end of the block or acting part of the wedge, and the resistance being at the point where the fibres begin to separate.

All the various kinds of cutting and piercing tools, as axes, knives, scissors, chisels, &c., nails, pins, awls, &c., are modifications of the wedge. The angle in these cases is more or less acute, according to the purpose to which it is applied. The mechanical advantage is increased by diminishing the angle of the wedge; but the strength of the tool is thereby also diminished. In tools for cutting wood the angle is generally about 30°; for iron it is from 50° to 60°; and for brass from 80° to 90°. In general, the softer the substance to be divided is, the more acute may the wedge be constructed.

WEFT is the name of the yarns or threads which run from selvage to selvage in a web.

WELD is an annual herbaceous plant, which grows all over Europe, called by botanists *Reseda luteola*. The stems and the leaves dye yellow; and among the dyes of organic nature, they rank next to the Persian berry for the beauty and fastness of color. The whole plant is cropped when in seed, at which period its dyeing power is greatest; and after being simply dried, it is brought into the market.

Chevreul has discovered a yellow coloring principle in weld, which he has called *luteoline*. It may be sublimed, and thus obtained in long needle-form, transparent, yellow crystals. Luteoline is but sparingly soluble in water; but it nevertheless dyes alumed silk and wool of a fine jonquil color. It is soluble in alcohol and ether; it combines with acids, and especially with bases.

When weld is to be employed in the dye-bath, it should be boiled for three quarters of an hour; after which the exhausted plant is taken out, because it occupies too much room. The decoction is rapidly decomposed in the air, and ought therefore to be made only when it is wanted.

WELDING is the property which pieces of wrought iron possess, when heated to whiteness, of uniting intimately and permanently under the hammer, into one body, without any appearance of junction. The welding temperature is usually estimated at from 60° to 90° of Wedgewood. When a skilful blacksmith is about to perform the welding operation, he watches minutely the effect of the heat in his forge-fire upon the two iron bars; and if he perceives them beginning to burn, he pulls them out, rolls them in sand, which forms a glassy silicate of iron upon the surface, so as to prevent further oxidizement; and then laying the one properly upon the other, he incorporates them by his right-hand hammer, being assisted by another workman, who strikes the metal at the same time with a heavy forge-hammer.

Platinum is not susceptible of being welded, although usually said to be.

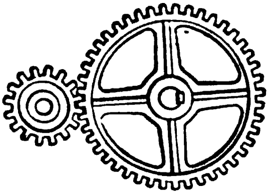
WHALEBONE is the name of the horny laminæ, consisting of fibres laid lengthwise, found in the mouth of the whale, which, by the fringes upon their edges, enable the animal to allow the water to flow out, as through rows of teeth (which it wants), from between its capacious jaws, but to catch and detain the minute creatures upon which it feeds. The fibres of whalebone have little lateral cohesion, as they are not transversely decussated, and may, therefore, be readily detached in the form of long filaments or bristles. The *blades*, or scythe-shaped plates, are externally compact, smooth, and susceptible of a good polish. They are connected, in a parallel series, by what is called the *gum* of the animal, and are arranged along each side of its mouth, to the number of about 300. The length of the longest *blade*, which is usually found near the middle of the series, is the gauge adopted by the fishermen to designate the size of the fish. The greatest length hitherto known has been 15 feet, but it rarely exceeds 12 or 13. The breadth, at the root end, is from 10 to 12 inches; and the average thickness, from four to five-tenths of an inch. The series, viewed altogether in the mouth of the whale, resemble, in general form, the roof of a house. They are cleaned and softened before cutting, by boiling for two hours in a long copper.

From its flexibility, strength, elasticity, and lightness, whalebone is employed for many purposes: for ribs to umbrellas or parasols; for stiffening stays; for the framework of hats, &c. When heated by steam, or a sand-bath, it softens, and may be bent or moulded, like horn, into various shapes, which it retains, if cooled under compression. In this way, snuff-boxes, and knobs of walking-sticks, may be made from the thicker parts of the blade. The surface is polished at first with ground pumice-stone, felt, and water; and finished with dry quicklime, spontaneously slaked, and sifted.

WHEEL WORK, in machinery, consists of a combination of wheels communicating motion to one another. Such combinations may be formed in various ways; but they are generally reducible to the principle of the wheel and axle, though the wheel, which turns the other, is not usually on the same axis with it. The motion in such cases is communicated from the one wheel to the other, either by belts or straps passing over the circumferences of both, or by teeth cut in those circumferences, and working in one another. In either of these ways the velocities of points in their circumferences are equal; and consequently their angular velocities, or the number of revolutions which they make in the same time, are inversely as their radii. When one wheel drives another by teeth, they necessarily turn in opposite directions; if united by a cord or belt, they will turn in the same direction, if the belt does not cross itself between the two wheels; but if the belt crosses itself, they will turn in opposite directions. The chief advantage of transmitting motion by cords or belts is, that the wheels may be placed at any convenient distance from each other, and be made to turn either in the same or in opposite directions.

Wheels may act on one another, so as to communicate motion in various ways. When the resistance of the work is not great, the object may be accomplished by the mere friction of their circumferences. In order to increase the friction, the surfaces of the rims are faced with buff leather (caoutchouc might answer the purpose better), or wood cut against the grain, and pressed together with a certain degree of force. This method is sometimes used in spinning machinery, and has even been applied successfully to the saw-mill; but it is seldom adopted in works on a great scale. Motion communicated in this manner proceeds smoothly and evenly, and is accompanied with little noise.

When motion is to be transmitted through a train of wheel work, toothed wheels are generally employed. It is usual to call a small wheel acted on by a large one a *pinion*, and its teeth the *leaves* of the pinion. Wheels and pinions are combined variously, sometimes as in the annexed cut; at other times, the axle of the wheel, which bears the power, is a pinion, which drives the second wheel. The axle of this wheel carries a pinion, which drives the third wheel. When motion is communicated in this manner, the angular velocity of the first wheel is to that of the last pinion as the product formed by multiplying together the radii of all the wheels to the product formed by multiplying together the radii of all the pinions. Consequently, if R, R′, R″, &c., denote respectively the radii of the wheels, and r, r' r'', &c., the radii of the pinions, we shall have, by the principle of virtual velocities $p\ (R \times R' \times R'', \&c.) = w\ (r \times r' \times r'', \&c.)$ As the size of the teeth of any wheel and the pinion into which it works must be equal, we may substitute for the radii the number of teeth in the wheels and pinions respectively.



Toothed wheels, as distinguished by the position of the teeth relatively to the axis, are of three kinds: *spur wheels*, *crown wheels*, and *bevelled wheels*. When the teeth are raised upon the edge of the wheel, or are perpendicular to the axis (as in the above figure), the wheel is a spur wheel; when they are raised parallel to the axis, or perpendicular to the plane of a wheel, it is a crown wheel; and when they are raised on a surface inclined to the plane of the wheel, it is called a bevelled wheel. The combination of a crown wheel with a spur wheel as pinion

is used when it is required to communicate motion round one axis to another at right angles to it. Two bevelled wheels are employed to transmit motion from one axis to another inclined to it at any proposed angle. Wheels have also different names, according to their mode of action, as *heart wheel, sun-and-planet wheel.*

Form of the Teeth of Wheels.—In the construction of machinery, it is of the utmost importance that the several parts act on one another with a uniform force, and with the smallest possible amount of friction. When wheels act by teeth working into each other, every point of the side of the tooth which is in action comes successively into contact with the tooth of the pinion as the wheel turns round, and the force is necessarily exerted at the points which are in contact. Hence the lengths and positions of A *c* (A being supposed the centre of the wheel and *c* the point) and B *c*, the levers by which they act, are constantly changing; and in order, therefore, that the force of the one tooth upon the other may be constant, it is necessary that the line drawn perpendicular to the surfaces of both teeth, at the point of contact *c*, always intersect the line A B of the centres in the same point. There are many different curves according to which the teeth might be formed so as to answer this condition; but that which has been most generally adopted, and which appears the most convenient, is the epicycloid generated by the revolution of a circle whose radius is equal to half the radius of the pinion on the circumference of a circle equal to the wheel. This was first proposed by Roemer, the celebrated Danish astronomer. The evolute of the circle was proposed, with other curves, by Euler.

When the teeth are constructed according to the theoretical rules, the action is not only uniform, but there is little friction; for the teeth roll on one another, and neither slide nor rub. But as it is impossible to attain perfect accuracy in practice, the surfaces of the teeth will always present some inequalities, and there will consequently be some friction. In order, therefore, to equalize the wear, it is necessary that every leaf of the pinion should work in succession through every tooth of the wheel, and not always through the same set of teeth; and hence the number of teeth in a wheel and in a pinion which work into each other should be prime to one another. This precaution is more especially necessary in mill-work, and where considerable force is used.

WHEELS OF CARRIAGES. Wheels consist of the *nave* or stock, in the centre, the *spokes* which are radii, and the *ring*, which is the periphery of the wheel. When a wheel is to be made, the workman adapts moulds to its exact diameter. Twelve spokes are commonly assigned to the larger wheels of carriages, and ten to the smaller ones. The working and finishing of the several fellies, to form the periphery of a wheel, consists, after it has been roughly chopped to the pattern, in forming its inside edge somewhat rounding, and getting its outside edge perfectly circular, and to form such an acute angle, that, when the wheel is adapted to the axle-tree, it shall stand square and solid under the body of the carriage.

The strength of a wheel depends greatly on the attention paid to the arrangement and framing of the spokes; in common wheels they are framed regularly and equally all round the thickest part of the nave, the tenons of the spokes being so bevelled as to stand, with reference to the horizontal position of the nave, about three inches out of the perpendicular: this is done to produce what is called dishing. But, for wheels of strength, such as the wheels of road coaches, the framing of the spokes consists in getting every other one perpendicular to the nave. Hence the mortises to receive them in it are not made in a parallel line round it, but stand, in two different parallels, one without the other, by which greater solidity is given to the nave, and an immense addition of strength.

The boxing of a wheel, and adapting the axle-tree, is done usually by the coach or tire-smith. The box of a wheel is a hollow conical tube of iron, furnished on its outside with two or three square projections, which have the effect of giving it a key when mortised through the nave of the wheel. Patent boxes are of a different construction, and owe their safety to four bolts, which pass completely through the nave of the wheel, having a square shoulder on the back of the nave, with screws and nuts on its front. The box to such a wheel is made, as are the other boxes above described, except being completely closed at its outer end, with a solid and broad cap of iron, of sufficient diameter to inclose completely the end of the nave. The axle-tree, too, is formed to fill the box, and press up close to this iron cap.

High wheels are, in bad roads, much preferable to low ones, except where the shape of any inequality of the road permits the low wheel to *roll*, while the larger wheel can bear only on the edges of the hole over which it is to pass. But the increased expense and weight of very large wheels put a limit to their size, beyond which no experienced mechanic would pass. For, although the mechanical power of a wheel in surmounting a given obstacle constantly increases with the size of the wheel, it does not increase *directly* in proportion to its height. It increases but little more than in proportion to *the square roots* of the diameter of the wheel; so that if a wheel pass over an obstacle with a given power, though it may be made to pass over the same obstacle with half that power by increasing the diameter of the wheel, it is not to be expected that this can be done by making the wheel twice as large: for, to effect this purpose, a wheel of *four times* the former diameter must be employed.

Mr. Edgeworth showed that practice agrees with theory. A wheel of seven inches diameter, loaded with twenty pounds, required eight pounds to draw it over an obstacle of one quarter of an inch high, whereas, when a wheel of twenty-eight inches high was employed, four pounds drew the same load over the same obstacle. And when the line of draught was horizontal, the larger wheel required four pounds four ounces, the smaller nine pounds.

It appears, that the higher the wheels the more advantageous is the draught: but, in fact, the expense, the strength, and the weight of wheels must be taken into account, when they are applied to carriages; and experience has determined, that the best height of wheels is from four feet six inches to five feet, for coaches and carriages that move swiftly; and that, for heavy carriages, wheels seldom are found useful beyond the diameter of six feet.

As narrow wheels always sink into the ground, especially when the heaviest part of the load lies upon them, they must be considered as going constantly up-hill, even on level ground. And their sides must sustain a great deal of friction by rubbing against the ruts made by others. But both these inconveniences are avoided by broad wheels; which, instead of cutting and ploughing up the roads, roll them smooth and harden them, as experience testifies, in places where they have been used, especially either on wettish or sandy ground. The fore-wheels of all carriages ought to be so high as to have their axles even with the breasts of the horses, which would not only give the horses a fair draught, but likewise cause the machine to be drawn by a less degree of power.

When the spokes are inclined to the nave, the wheels are said to be concave, or dishing. But it is allowed, on all hands, that perpendicular spokes are preferable on level ground. The inclination of the spokes, therefore, which may render concave wheels advantageous in rugged and unequal roads, renders them disadvantageous when the roads are in good order.

M. Camus showed that the line of traction should be a horizontal line, or rather, that it should always be *parallel to the ground on which the carriage is moving*, both because the horse can exert his greatest strength in this direction, and because the line of draught, being perpendicular to the vertical spoke of the wheel, acts with the greatest possible leverage. M. Deparcieux shows, in the most satisfactory manner, that animals draw by their weight, joined to the force of their muscles. In four-footed animals, the hind-feet are the fulcrum of the lever by which their weight acts against the load, and when the animal pulls hard, it depresses its chest, and thus increases the lever of its weight, and diminishes the lever by which the load resists its efforts.

Noiseless wheels.—A patent has been taken out for dulling the sound of wheels. In this instance the invention consists in the application of a solid band of vulcanized India-rubber over the iron tire of the wheel. The India-rubber is held in its place by the tire having a raised rim on both sides, and by its own elasticity. The band of an ordinary carriage wheel is about an inch to one inch and a half in thickness, and, unless on close inspection, no difference from the common iron-shod wheel is perceptible. We have driven some distance in a carriage with the wheels so shod, and were struck, not only with its noiselessness, but at the perfect smoothness of the motion—the wheels being, in fact, springs, and, by their elasticity, giving a lighter draught than with the iron tire. One set of wheels, which have been driven 4000 miles, have here and there a trifling cut, but show no appearance of being worn out, and seem quite capable of another three or four thousand. An iron tire is generally worn out in 8,000 miles, so that the India rubber tire has so far proved itself the more lasting. It is certainly a great addition to the luxury of a carriage to have it run without jar or noise; and it would be a universal comfort to have the streets of cities without the present incessant rattle of carriages, omnibuses, &c.

WHITE LEAD. *Carbonate of Lead; Painters' White.* Lead is converted into carbonate in the following way:—The metal is cast into the form of a network grating, in moulds about fifteen inches long, and four or five broad. Several rows of these are placed over cylindrical glazed earthen pots, about four or five inches in diameter, containing some treacle-vinegar, which are then covered with straw; above these pots another range is piled, and so in succession, to a convenient height. The whole are imbedded in spent bark from the tan-pit, brought into a fermenting state by being mixed with some bark used in a previous process. The pots are left undisturbed under the influence of a fermenting temperature for eight or nine weeks. In the course of this time the lead gratings become, generally speaking, converted throughout into a solid carbonate, which when removed is levigated in a proper mill, and elutriated with abundance of pure water. The plan of inserting coils of sheet lead into earthenware pipkins containing vinegar, and imbedding the pile of pipkins in fermenting horse-dung and litter, is now little used; because the coil is not uniformly acted on by the acid vapors, and the sulphureted hydrogen evolved from the dung is apt to darken the white lead.

In the above processes, the conversion of lead into carbonate seems to be effected by keeping the metal immersed in a warm, humid atmosphere, loaded with carbonic and acetic acids; and hence a pure vinegar does not answer well, but one which is susceptible, by its spontaneous decomposition in these circumstances, of yielding carbonic acid. Such are tartar, wine lees, molasses, &c.

Another process has been practised to a considerable extent in France, though it does not afford a white lead equal in body and opacity to the products of the preceding operations. M. Thenard first established the principle, and MM. Brechoz and Leseur contrived the arrangements of this new method, which was subsequently executed on a great scale by MM. Roard and Brechoz.

A subacetate of lead is formed by digesting a cold solution of uncrystallized acetate, over litharge, with frequent agitation. It is said that 65 pounds of purified pyroligneous acid, of specific gravity 1·056, require, for making a neutral acetate, 58 pounds of litharge; and hence, to form the subacetate, three times that quantity of base, or 174 pounds, must be used. The compound is diluted with water as soon as it is formed, and being decanted off quite limpid, is exposed to a current of carbonic acid gas, which, uniting with the two extra proportions of oxide of lead in the subacetate, precipitates them in the form of a white carbonate, while the liquid becomes a faintly acidulous acetate. The carbonic acid may be extricated from chalk, or other compounds, or generated by combustion of charcoal, as at Clichy; but in the latter case, it must be transmitted through a solution of acetate of lead before being admitted into the subacetate, to deprive it of any particles of sulphureted hydrogen. When the precipitation of the carbonate of lead is completed, and well settled down, the supernatant acetate is decanted off, and made to act on another dose of litharge. The deposit being first rinsed with a little water, this washing is added to the acetate; after which the white lead is thoroughly elutriated. This repetition of the process may be indefinitely made; but there is always a small loss of acetate, which must be repaired, either directly or by adding some vinegar.

WHITING. Chalk carefully cleared of all stony matter, ground, levigated, and made up into small oblong cakes. As it is often used as a polishing material, it should be very carefully freed from all particles of flint or sand.

WHITE VITRIOL. The old name of sulphate of zinc. (*See* ZINC.)

WHITEWASH. A mixture of whiting, size, and water, for whitening ceilings and walls.

WINCH. In mechanics, a bent handle or rectangular lever, for turning a wheel, grindstone, &c. The term *winch* is also popularly applied to the *windlass.* (*See* WINDLASS.)

WINDLASS. A machine used for many common purposes. It is a particular modification of the wheel and axle, the power being applied by means of a rectangular lever or *winch.* The arm of the winch represents the radius of the wheel; and the power is applied at right angles. The windlass is frequently used in merchant ships or small trading vessels instead of a *capstan* for heaving the anchors, &c. In this case it consists of a large cylindrical piece of timber laid in a horizontal position, and supported at its two ends by two pieces of wood called *knight-heads* placed on opposite sides of the deck near the foremast. This axle is pierced with holes directed towards the centre, in which long levers are inserted, called handspikes. It is furnished with strong *pauls* to prevent it from turning backwards when the pressure on the handspikes is intermitted.

WINDMILL. In mechanics, a mill which receives its motion from the impulse of the wind. The general appearance of the windmill is familiar to every one. The building containing the machinery is usually circular. To the extremity of the principal axis, or wind-shaft, are attached rectangular frames (generally five), on which cloth is usually stretched to form the sails. The surfaces of the sails are not perpendicular to the axis, but inclined to it at a certain angle, about 72° at the extremities nearest to the axle, and 83° at the farther extremities; so that their form is in some degree twisted, and different from a plane surface. Suppose the axis to be placed in the direction of the wind; the wind will then strike the sail obliquely, and the force may therefore be resolved into two parts, one of which, acting in the direction perpendicular to the axis, gives a motion of rotation to the sails, and consequently to the wind-shaft, from which it is communicated to the machinery. The wind-shaft is inclined to the horizon in an angle of from 8° to 15°, principally with a view to allow room for the action of the wind at the lower part, where it would be weakened if the sails came too nearly in contact with the building.

As the direction of the wind is constantly changing, some apparatus is required for bringing the axle and sails into their proper position. This is sometimes effected by supporting the machinery on a strong vertical axis, the pivot of which moves in a socket firmly fixed in the ground; so that the whole structure may be turned round by a lever. But it is now usual to construct the building with a movable roof, which revolves upon friction rollers; and the shaft being fixed in the roof is brought round along with it. The roof is brought into the required position by means of a small vane wheel furnished with wind sails, which turns round when the wind strikes on either side of it, and drives a pinion which works into the teeth of a large crown wheel connected with and surrounding the movable roof.

Of the form and position of the sails.—From the investigations of Parent and Belidor, it appears that the maximum effect of the wind on the sails is produced when their inclination to the axis of rotation is about 54¾ degrees; or when the *angle of weather*, that is to say, the angle formed by the plane of the sail and the plane of its revolution, is 85¼ degrees. But this result, being obtained from considering the effect of the wind on the sails when at rest, does not agree with that which is found by experiment. In fact, as the velocity of the sail tends to withdraw it from the wind, it is necessary to counteract the diminution of force by diminishing the angle of weather, or to bring the sail into such a position that the wind strikes its surface more directly: and since the velocity of the different parts of the sail is in proportion to their distance from the axis, it follows that in order to produce the greatest effect every elementary portion of it ought to have a different angle of weather, diminishing from the centre to the extremity of the sail.

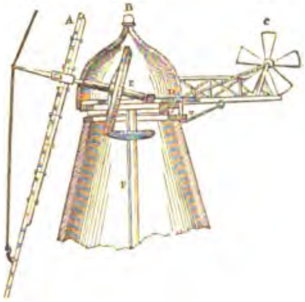
From the experiments of Smeaton, it appears that the following positions are the best. Suppose the radius to be divided into six equal parts, and call the first part, beginning from the centre, one, the second two, and so on, the extreme part being six:—

No.	Angle with the Axis.	Angle with the Plane of Motion, or Angle of Weather.
1	72°	18°
2	71	19
3	72	18
4	74	16
5	77½	12½
6	83	7

As it is necessary that a windmill should face the wind from whatever point it blows, the whole mill is made to turn upon a strong vertical post, and is therefore called a *post-mill;* but, commonly, the roof or head only revolves, carrying with it the windwheel and its shaft, the weight being supported on friction rollers.

The following are the maxims of Smeaton with regard to mills:—1. The velocity of windmill sails, whether loaded or unloaded, so as to produce a maximum

effect, is nearly as the velocity of the wind, their shape and position being the same. **2. The load at the maximum is nearly, but somewhat less, as the square of the velocity of the wind, the shape and position of the sails being the same. 3.** The effects of the same sails at a maximum are nearly, but somewhat less, as the cubes of the velocity of the wind. 4. The load of the same sails at the maximum is nearly as the squares, and their effects as the cubes, of their number of turns in a given time. 5. When the sails are loaded so as to produce a maximum effect at a given velocity, and the velocity of the wind increases, the load continuing the same, then the increase of effect, when the increase of the velocity of the wind is small, will be nearly as the square of those velocities; when the velocity of the wind is doubled, the effect is nearly as 10 to 27¼. When the velocities compared are more than double of that where the given load produces a maximum, the effects compared increase nearly in the same ratio of the velocity of the wind. 6. In sails where the positions and figures are similar and the velocity of the wind the same, the number of turns in a given time will be reciprocally as the radius or length of the sail. 7. The load at a maximum that sails of a similar figure and position will overcome at a given distance from the centre of motion will be as the cube of the radius. 8. The effects of sails of similar figure and position are as the square of the radius. 9. The velocity of the extremities of Dutch sails, as well as of the enlarged sails in all their usual positions, when unloaded, or even loaded to a maximum, is considerably quicker than the velocity of the wind.



Horizontal windmills.—Windmills are sometimes constructed in such a manner that the planes of the sails intersect each other in the wind-shaft, in which case they are called *horizontal windmills*; because the wind-shaft being usually vertical, the sails have a horizontal motion. The wind-shaft, however, might be placed with equal advantage in the horizontal position.

In order that motion may be communicated to the machine, the impulse of the wind on the returning sail must be removed by screening it from the wind, or at least diminished by making it present a less surface when returning against the wind. The first of these methods is said to be practised in Tartary, and some provinces in Spain; it is the simplest and probably the best. The other method requires the sail to be formed of several flaps movable on hinges, and so adjusted that on one side of the axis they present their surfaces to the wind, and when returning on the other only their edges. Other contrivances have been proposed; but horizontal windmills are greatly inferior, in point of effect, to those which have vertical sails, and are accordingly seldom met with.

On account of the irregularity of the moving force, and the interruption of calm weather, machines impelled by the wind can only be used advantageously for purposes which are not urgent, and where regularity is not indispensable. The chief purposes to which they are applied are grinding corn, expressing oil from seeds, bruising oak bark for tanning, sawing wood, raising water, &c. Windmills were brought into Europe from the East about the time of the Crusades; they are not much used in this country.

WINDOW. In architecture, an aperture in a wall for the admission of light and air to the interior. In distributing windows so that there be had a sufficiency of light, it is usual to make the piers or intervals between them never less than the width of the window, and never more than two-widths of the same. Where it is required to ascertain the total area of light necessary for a room, the following empirical rule is frequently used: Multiply together the length, breadth, and height, and extract the square root of the product, which will be the area of light required.

WINDSOR-BRICK is an infusible material, light, and easily cut into desirable forms, with the knife or saw, for the use of chemists and manufacturers.

WIRE-DRAWING. The art of extending the ductile metals into wire.

The operation is performed by casting or hammering the metal into a bar, which is then successively drawn through holes in a steel plate, each being smaller than the other, until the requisite fineness is attained. The holes through which extremely fine wires of platinum, gold, or silver are occasionally drawn, are sometimes made in a diamond or ruby. (*See* GOLD and SILVER.)

WOAD. A continental European plant, which yields a blue dye to woollen cloth. The large leaves are gathered, in France, several times in a year, and ground into paste at a mill. It is then laid in heaps to ferment, formed into balls, and dried. The dyers pound it again, and ferment it with water. It is then dissolved in boiling water, and a 20th slaked lime added, by which it ferments, turns blue and red, and finally dyes woollens green, which, in the air, change to blue. Woad grows luxuriantly in this country.

WOOD, in plants, physiologically considered, is the support of all the deciduous organs of respiration, digestion, and impregnation; the deposit of the secretions peculiar to the individual species; and also the reservoir from which the newly forming parts derive their sustenance until they can establish a communication with the soil. It consists organically of woody tissue, and various kinds of vessels surrounded by cellular matter, and more or less carefully arranged. In the youngest state it is succulent and brittle, and is of nearly the same quality in all plants; but as it gains age, the sides of the woody tissues become hardened and thickened by the deposit within them of matter of solidification, and wood then assumes the colors and appearances peculiar to different species. In the young state it is called *sapwood* or *alburnum*; when hardened and colored it becomes *duramen* or *heartwood*. It abounds in nitrogen, which may be removed by simple washing; and it is supposed that the perishable quality of wood is owing to the presence of this element. It is believed that the preserving power of certain agents employed to render wood durable depends upon their rendering the azotized matter insoluble.

WOOD COAL. A synonym of brown coal.

WOOD ENGRAVING. (*See* ENGRAVING.)

WOOD OPAL. An opalized quartz occurring in various vegetable forms.

WOODSTONE. Petrified wood.

WOOD TIN. An opaque, fibrous, and nodular variety of oxide of tin, of a brown color, hitherto only found in Cornwall.

WOODY FIBRE. Very slender, transparent membranous tubes, tapering acutely to each end, lying in bundles in the tissue of plants, and having no direct communication with each other. They are of extreme tenuity, and form the substances called hemp and flax.

WOOD PRESERVATION. If properly seasoned, timber, placed in a dry situation with a free circulation of air round it, is very durable, and has been known to last for several hundred years without apparent deterioration. This is not, however, the case when exposed to moisture, which is always more or less prejudicial to its durability.

When timber is constantly under water, the action of the water dissolves a portion of its substance, which is made apparent by its becoming covered with a coat of slime. If it be exposed to alternations of dryness and moisture, as in the case of piles in tidal waters, the dissolved parts being continually removed by evaporation and the action of the water, new surfaces are exposed, and the wood rapidly decays.

Where timber is exposed to heat and moisture, the albumen or gelatinous matter in the sapwood speedily putrefies and decomposes, causing what is called rot. The rot in timber is commonly divided into two kinds, the *wet* and the *dry*; but the chief difference between them is, that where the timber is exposed to the air, the gaseous products are freely evaporated; whilst, in a confined situation, they combine in a new form, viz., the dry-rot fungus, which, deriving its nourishment from the decaying timber, often grows to a length of many feet, spreading in every direction, and insinuating its delicate fibres even through the joints of brick walls.

In addition to the sources of decay above mentioned, timber placed in sea water is very liable to be completely destroyed by the perforations of the worm, unless protected by copper sheathing.

The best method of protecting woodwork from decay, when exposed to the weather, is to paint it thoroughly, so as to prevent its being affected by moisture.

It is, however, most important not to apply paint to any wood-work which has not been thoroughly seasoned; for in this case the evaporation of the sap being prevented, it decomposes, and the wood rapidly decays.

Many plans have been proposed for the prevention of the rot. Kyan's process consists in impregnating the timber with corrosive sublimate, thus converting the albumen into an indecomposable substance. This method, although not always successful, is undoubtedly of great use, particularly where inferior or imperfectly seasoned timber has to be used. It is, however, said to render the wood brittle.

Payens's process consists in impregnating the wood with metallic oxides, alkalies, or earths, as may be required, and decomposing them in the wood, forming new and insoluble compounds. The usual preparation was first injecting into the timber a solution of sulphate of iron, and then one of chloride of calcium. An air pump was used to draw the liquids into the pores of the wood. Timber thus prepared will not burn, but only smoulders.

A process invented by a Mr. Bethell, and very good in railway works, is to impregnate the timber with oil of tar: this appears to be very successful in preventing decay, but the danger of accidents from fire is much increased.

Dr. Boucherie's process of impregnating timber was with a solution of sulphate of copper. After the varnishing, the appearance of the wood is rich, and is said to be permanent. The Dr. confines his application of it to the soft wood generally; and he exhibited at a French meeting a work-box so impregnated, made of a tree within three months after it was cut. He showed a block sawed into three sections, but not disconnected, which had been buried for six years in a fungus pit. It is of pine, and immediately after being felled, the two side sections were impregnated by means of the natural action of the sap vessels of the wood, the one with the deuto-chloride of mercury (corrosive sublimate, as recommended by Kyan), 800 grammes of 1-5 per cent. strength; the other with 800 grammes of sulphate of copper, of 1-5 per cent. The centre section was left in its natural state. The block shows the portions which were left in a natural state, and that impregnated with the corrosive sublimate, equally and completely rotten, the fibre destroyed, and the wood crumbling into dust, while the section marked as impregnated with the sulphate is perfectly sound and good. It is said, that traversers and sleepers on railways so impregnated have been used six years, and are still sound.

WOOL. A term used very indefinitely, being applied both to the fine hair of animals, as sheep, rabbits, some species of goats, &c., and to fine vegetable fibres, as cotton (called in German baumwolle, or *tree-wool*); but when used without restriction it is generally confined to the wool of sheep—a substance which, from the remotest period of history, has been of primary importance to mankind. In reference to textile fabrics, sheep's wool is of two different sorts, the short and the long stapled; each of which requires different modes of manufacture in the preparation and spinning processes, as also in the treatment of the cloth after it is woven, to fit it for the market. Each of these is, moreover, distinguished in commerce by the names of fleece wools and dead wools, according as they have been shorn at the usual annual period from the living animal, or are cut from its skin after death. The latter are comparatively harsh, weak, and incapable of imbibing the dyeing principles, more especially if the sheep has died of some malignant distemper. The annular pores, leading into the tubular cavities of the filaments, seem, in this case, to have shrunk and become obstructed. The time of year for sheep-shearing most favorable to the quality of the wool and the comfort of the animal, is towards the end of June and the beginning of July in England; in this country it is somewhat later: generally in the month of August.

The wool of the sheep has been surprisingly improved by its domestic culture. The *mouflon* (*Ovis aries*), the parent stock from which our sheep is undoubtedly derived, and which is still found in a wild state upon the mountains of Sardinia, Corsica, Barbary, Greece, and Asia Minor, has a very short and coarse fleece, more like hair than wool. When this animal is brought under the fostering care of man, the rank fibres gradually disappear; while the soft wool round their roots, little conspicuous in the wild animal, becomes singularly developed. The male most speedily undergoes this change, and continues ever afterward to possess far more power in modifying the fleece of the offspring than the female parent. The produce of a breed from a coarse-woolled ewe and a fine-woolled ram is not of a mean quality between the two, but halfway nearer that of the sire. By coupling the female thus generated with such a male as the former, another improvement of one half will be obtained, affording a staple three fourths finer than that of the grandam. By proceeding inversely, the wool would be as rapidly deteriorated. It is, therefore, a matter of the first consequence in wool husbandry, to exclude from the flock all coarse-fleeced rams.

Long wool is the produce of a peculiar variety of sheep, and varies in the length of its fibres from 3 to 8 inches. Such wool is not carded like cotton, but combed like flax, either by hand or appropriate machinery. Short wool is seldom longer than 3 or 4 inches; it is susceptible of carding and felting, by which processes the filaments become first convoluted, and then densely matted together. The shorter sorts of the combing wool are used principally for hosiery, though of late years the finer kinds have been extensively worked up into merino and mousseline-de-laine fabrics. The longer wools of the Leicestershire breed are manufactured into hard yarns, for worsted pieces, such as waistcoats, carpets, bombazines, poplins, crapes, &c.

The wool of which good broadcloth is made should be not only shorter, but, generally speaking, finer and softer than the worsted wools, in order to fit them for the fulling process. Some wool-sorters and wool-staplers acquire by practice great nicety of discernment in judging of wools by the touch and traction of the fingers. Dr. Ure made a large series of observations upon different wools, and published the results. The filaments of the finer qualities varied in thickness from 1-1100th to 1-1500th of an inch; their structure is very curious, exhibiting, in a good achromatic microscope, at intervals of about 1-300th of an inch, a series of serrated rings, imbricated towards each other, like the joints of *Equisetum*, or, rather, like the scaly zones of a serpent's skin.

There are four distinct qualities of wool upon every sheep; the finest being upon the spine, from the neck to within six inches of the tail, including one third of the breadth of the back; the second covers the flanks between the thighs and the shoulders; the third clothes the neck and the rump; and the fourth extends upon the lower part of the neck and breast down to the feet, as also upon a part of the shoulders and the thighs, to the bottom of the hind quarter. These should be torn asunder, and sorted, immediately after the shearing.

The harshness of wools is dependent not solely upon the breed of the animal, or the climate, but is owing to certain peculiarities in the pasture, derived from the soil. It is known that in sheep fed upon chalky districts, wool is apt to get coarse; but in those upon a rich loamy soil, it becomes soft and silky. The ardent sun of Spain renders the fleece of the Merino breed harsher than it is in the milder climate of Saxony. Smearing sheep with a mixture of tar and butter is deemed favorable to the softness of their wool. This breed flourishes well in New England.

All wool, in its natural state, contains a quantity of a peculiar potash-soap, secreted by the animal, called in this country the *yolk;* which may be washed out by water alone, with which it forms a sort of lather. It constitutes from 25 to 50 per cent. of the wool, being most abundant in the Merino breed of sheep; and however favorable to the growth of the wool on the living animal, should be taken out soon after it is shorn, lest it injure the fibres by fermentation, and cause them to become hard and brittle. After being washed in water, something more than lukewarm, the wool should be well pressed and carefully dried.

Wool is much cultivated in the New-England States, especially in Vermont.

WOOLLEN MANUFACTURE. The simplest mode of giving an idea of the extent of operations in a woollen manufactory, is to give in abridgment the heads of the several processes which the wool undergoes until it comes out fitted for the market. Thus, no less than 25 processes may be enumerated:

1. There are men employed in *sorting* the wools of many qualities and countries.
2. There is a machine of many rollers with teeth, for what is called *devilling*, or willowing the wool, which means the opening of its locks.
3. There are machines for *scribbling* or combing it.
4. There are others, called *carders*, for forming slivers, or short rolls of the wool.
5. There is a travelling or sliding apparatus called a *billy*, for *slubbing* or drawing out the slivers into six times their length.
6. The slubbings put on spindles are then *spun* by means of *mules*, machines well known in cotton factories, and invented by Crompton, who lately died in poverty at Bury.
7. The thread is then formed, by women, into *warps* for the looms.
8. The weavers *size* and dry these warps or webs.

9. They then fix them on their beams, and *weave* the cloth, which, as delivered by them, is little better, or firmer, than stout flannel.

10. This cloth is then *scoured*.

11. It is afterwards taken to the *burlers*, a room of women, who pick the surface and clear the whole from foreign substances.

12. The cloth is then *milled*, a process most curious, in which, by being beat with wooden hammers of 3 cwt. each, for 15 or 24 hours, the threads of the web are driven together, and the width reduced from 11 quarters, or 8 feet 3 inches, to 5 feet. The machines are called *stocks*. The backs are made of cast-iron, and the circular blows of the hammers, and the harmony of the result is astonishing.

13. The next process is to confer *a soft nap* on one side of the cloth; and this is effected by the use of a species of thistle, called *teasels*, the heads of which are placed in frames, put upon cylinders, and against these the cloth is worked for 6 or 7 hours, by which means a delicate and lustrous nap is raised, which constitutes the beauty of cloth.

14. It is then *boiled* in water for two hours, by which its glossy surface is fixed.

15. It is then *cropt*, or reduced to a level surface, by means of sheer spiral blades, fixed upon a cylinder, invented by Mr. I. Collier, of Paris, a process formerly performed in a very clumsy manner by huge shears.

16. It is then boiled, *tentered*, and dried in a house, at a heat of 100° or 120°.

17. It is then worked, or *raised* again, by means of teasels, called *moysing*.

18. It is, finally, *cropt* lengthwise and breadthwise.

19. At this period it undergoes various *brushings*, by machines contrived for that purpose.

20. Imperfections are then *fine-drawn* by men.

21. It is *pressed*, by a Brahmah's hydraulic press, with a force of 100 tons, between hot iron plates.

22. The pressed face is taken off by *steaming* and *brushing*.

23. It is *cuttled* or folded into lengths, as pieces for sale.

24. If blue, the wool is dyed before the manufacturing.

25. If black, it is dyed after being milled.

Such are the numerous steps by which a piece of superfine woollen cloth is produced. It is 6 weeks in its course, or in work. The weaving occupies 3 or 4 weeks, and is the only part of the process which depends on the workman.

XANTHIC ACID. An acid composed of sulphur, carbon, hydrogen and oxygen, obtained in combination with potassa by agitating sulphuret of carbon mixed with solution of pure potassa in strong alcohol. Its compounds are mostly of a yellow color, whence its name. The relative proportions of its component parts have not as yet been satisfactorily obtained.

YEAST. The fermenting froth of worts.

YEAST, ARTIFICIAL. Mix two parts, by weight, of the fine flour of pale barley malt with one part of wheat flour. Stir 50 pounds of this mixture gradually into 100 quarts of cold water, with a wooden spatula, till it forms a smooth pap. Put this pap into a copper over a slow fire; stir it well till the temperature rise to fully 155° to 160°, when a partial formation to sugar will take place, but this sweetening must not be pushed too far; turn out the thinned paste into a flat cooler, and stir it from time to time. As soon as the wort has fallen to 59° Fahr., transfer it to a tub, and add for every 50 quarts of it 1 quart of good fresh beer-yeast, which will throw the wort into brisk fermentation in the course of 12 hours. This preparation will be good yeast, fit for bakers' and brewers' uses, and will continue fresh and active for 3 days. It should be occasionally stirred.

When beer-barm has become old and flat, but not sour, it may be revived by mixing with every quart of it a small potato, boiled, peeled, and rubbed down into a paste. The mixture is to be placed in a warm situation, where it will speedily show its renewed activity, by throwing up a froth upon its surface. It must be forthwith incorporated with the dough, for the purpose of baking bread. When the barm has become sour, its acid should be neutralized with a little powdered carbonate of soda, and then treated as above, when it will, in like manner, be revived. A bottle of brisk small beer may furnish ferment enough to form, in this way, a supply of good yeast for a small baking.

The German yeast employed by bakers in baking cakes and other *fancy* bread, is made by putting the *unterhefe* into thick sacks of linen or hempen yarn, letting the liquid part, or beer, drain away; placing the drained sacks between boards, and exposing them to a gradually increasing pressure, till a mass of a thin cheesy consistence is obtained. This cake is broken into small pieces, which are wrapped in separate linen cloths; these parcels are afterwards inclosed in wax-cloth, for exportation. The yeast cake may also be rammed hard into a pitched cask, which is to be closed air-tight. In this state, if kept cool, it may be preserved active for a considerable time. When this is to be used for beer, the proportion required should be mixed with a quantity of worts at 60° Fahr., and the mixture left for a little to work, and send up a lively froth, when it is quite ready for adding to the cooled worts in the fermenting back.

YEAST, PATENT. Boil 6 ounces of hops in 3 gallons of water 3 hours; strain it off, and let it stand 10 minutes; then add half a peck of ground malt, stir it well up, and cover it over; return the hops, and put the same quantity of water to them again, boiling them the same time as before, straining it off to the first mash; stir it up, and let it remain 4 hours, then strain it off, and set it to work at 90°, with 3 pints of patent yeast; let it stand about 20 hours; take the scum off the top, and strain it through a hair sieve; it will be then fit for use. One pint is sufficient to make a bushel of bread.

YENITE. A ferruginous silicate of lime, from Elba; named by Leliévre, its discoverer, in honor of the battle of Jena.

ZAFFRE. An impure oxide of *cobalt*, obtained by exposing the native arseniuret of cobalt broken into small pieces to the action of heat and air in a reverberating furnace, by which its elements are oxidized, and the greater part of the arsenic driven off.

ZANTHOPICRIN. A bitter principle, obtained from the bark of the *Zanthoxylon caribæum*. It forms yellow acicular crystals, insoluble in ether, but readily soluble in alcohol, and sparingly in water.

ZAX. In architecture, a tool for cutting slates.

ZECHSTEIN. A magnesian limestone, lying under the red sandstone.

ZEIN. A substance of a tough elastic nature, resembling gluten, but said to be destitute of nitrogen, contained in Indian wheat; the produce of the *Zea mays*.

ZEOLITE. A name given to a family of minerals, which, when heated before the blowpipe, melt with considerable ebullition. They mostly consist of silica, alumina, lime, and water.

ZERO. A term generally used in reference to the thermometer, implying the point at which the graduation commences. The zero of Reaumur's and of the centigrade thermometer is the freezing point of water. The zero of Fahrenheit's scale is 32° below the point at which water congeals, being about the temperature of a mixture of salt and snow. *See* THERMOMETER.

ZINC. A metal, first mentioned by Paracelsus; but its ores were known at a much earlier period. In commerce it is often called *spelter;* and is obtained either from the native carbonate of zinc, called *calamine*, or from the native sulphuret or *blende* of mineralogists. These ores are roasted and mixed with charcoal or carboniferous flux; the mixture is put into a kind of crucible closed at top, and perforated at bottom by an iron tube, which passes through the grate of the furnace into water; the vapor of the zinc distils downwards through this tube, and is condensed in the water. The first portions are impure, containing arsenic, and often cadmium, in which case the vapor burns with what the workmen call a *brown blaze;* when the *blue blaze* appears the zinc is collected. The zinc of commerce (which is not quite pure) has a peculiar bluish color and lustre, a lamellar and crystalline texture, and its specific gravity is about 7. At common temperatures it is tough and intractable under the hammer; and when heated to above 500° it becomes brittle, and fuses at about 770°. But at temperatures between 220° and 320° it becomes malleable and ductile; so that it may be beaten out under the hammer, and rolled into sheets and leaves, and drawn into wire, in a manner extremely remarkable when its highly crystalline texture is considered. Being a cheap and light metal, and one which, after having been superficially oxidized, long resists the further action of air and water, it has lately been much employed as a substitute for lead in lining water cisterns and covering buildings; it has also been lately employed in the curious operation of transferring printing (under the name of *zincography*). It is a very inflammable metal, burning in the flame of a spirit lamp with a brilliant white light; but the oxide which forms interferes with its continuous combustion, which can only be carried on at a high red heat, when the vapor of the metal burns with an intensely bright flame, and yields at the same time a quantity of flocculent oxide, which floats about in the surrounding air, and was formerly called *philosophers' wool*, *pompholix*, and *nihil album*. The equivalent of zinc is 32 and that of its oxide 40.

Though zinc is apparently without action upon water, yet it is a most oxidable metal; but the insolubility of its oxide protects it from farther action, so that when a film is once formed upon it, it resists further change; but when a little acid is present in the water, and the zinc not quite pure, it is rapidly acted upon, and oxidized at the expense of the water, which evolves abundance of hydrogen (when dilute sulphuric acid is used), and the oxide of zinc is removed and dissolved by the acid. It is this action which renders zinc so powerful a generator of electricity in the voltaic pile. The salts of zinc are mostly soluble, and have a nauseous astringent and metallic taste. The *sulphate of zinc*, or *white vitriol*, is employed in medicine as an emetic and tonic, and the oxide and carbonate are externally used in the form of ointment. The *chloride of zinc* is a colorless compound, fusible at a heat a little above 212°, and known to the older chemists under the name of *butter of zinc*. It is much used for soldering. Brass is an alloy of zinc and copper.

Franklinite, which is a carbonate of zinc mixed with silicates, is found abundantly in Sussex and Morris counties, N. J.; almost all the American zinc (which is of great purity) is manufactured from it. (*See* FRANKLINITE.)

Zinc, rolled into large plates, is employed as a substitute for lead and slates, in the roofing of buildings. The great advantage of these plates of zinc is their lightness, being only about one-sixth part of the weight of lead. They do not rust, which is another great advantage, and has led to the employment of zinc pipes both for cold and hot water. No covering is better adapted for verandas and summer houses.

ZIMOME. That part of the gluten of wheat which is insoluble in alcohol. When rubbed in a mortar with powdered guaiacum, it produces a fine blue color.

ZIRCON. A mineral chiefly composed of zirconia and silica, found in the sand of the rivers of Ceylon, and occasionally imbedded in primitive rocks. It is of various colors, and when transparent is sometimes used in jewelry.

ZIRCONIUM. The metallic base of *zirconia*, an earth discovered in 1789, by Klaproth, in the jargon or zircon of Ceylon. Zirconium has only been obtained in the form of a black powder, which, when heated in the air, burns into the oxide. The salts of zirconia are distinguished from those of alumina and glucina by being precipitated by all the pure alkalies, and by being insoluble when they are added in excess.

THE END.

ADDENDA.

HOSIERY. These fabrics are now made in this country with great rapidity by the assistance of the power-weaving loom — an invention of this country. This machine does ten times the work which is done daily by a single hand: a piece, 28 inches in width and 1 inch long, can be knit in one minute. The quantity of hosiery used in these States was valued in 1845 at $2,500,000; and the stockings, woven shirts, and drawers, made in this country, at $500,000.

PAINT MINERAL. Mr. Blake, of Akron, Ohio, has discovered a mineral in that neighborhood suitable for ordinary paint: when first dug up it is of the consistence of tallow, hardening in a few days, so as to resemble slate. It is of a dark blue color, and is impervious to water, and admits of a good polish. When powdered and mixed with linseed oil, it has the appearance of black paint, and is used for covering canvas, fences, barns, and out-door shedding: as it does not absorb the rain, it is an excellent covering in such situations. It consists of one half of silica, one fourth of alumina, with lesser proportions of magnesia, black oxide of iron, sulphuret of iron, lime, and carbonaceous matter. Many stiff clays of appropriate composition have been found, which answer the same purpose as this mineral from Akron.

PIN MANUFACTURE. This branch of industry has advanced much farther and more rapidly in this country than in England. In one manufactory in New England, the whole manufacture is carried out in every branch by machinery, and not by hand. In the factory at Derby, Conn., the pins are fastened in the paper by machinery. One woman pours into a hopper, by the gallon at a time, the pins, from whence they come out all neatly arranged upon their several papers. The machine is boxed up, and not allowed to be inspected. Above 300,000 pins are fastened on the paper in one day by this machine—a number which would occupy sixty women to do it by hand.

WOOD, PRESERVATION OF. The process patented in England by Mr. Payne (which, in itself, is a modification of Payen's French process), is now extensively carried out in this country. Two establishments of this nature are situated in the State of New York, one at Brooklyn, and the other at Rochester. In the latter city Messrs. Parsons, Child, and Rochester, have made an outlay of $20,000, and established extensive concerns there. The wood to be *paynized* is placed in a large cylinder 64 feet long, and 5 feet inside diameter, made of boiler iron, one half inch in thickness, strongly riveted, and capable of resisting a pressure of several hundred pounds to the square inch. The cylinder is placed horizontal, and raised a little off the floor; the timber is drawn into it by means of seven cast-iron cars, travelling upon a railroad that runs the entire length of the iron cylinder, upon iron ways. The cars and timber being carried inside the cylinder—the head of it, which weighs 2¼ tons, swung to and securely fastened—steam is then injected into the cylinder, softening the wood and expelling the air; the steam is then condensed by the flowing of cold water over the cylinder, and the admission of one of the *paynizing* fluids in jets (a solution of sulphate of iron). A vacuum is thus produced which is rendered almost perfect by a vacuum pump, in withdrawing the air. Beneath the cylinder are the vats containing the solutions for use. A tub closed by a valve runs from the cylinder to each of these vats, and when the valve is opened the flow of the solution into the cylinder is immediate and rapid. The sulphate of iron solution flows into all the open pores of the wood; after a few minutes this is drawn and the chloride of calcium solution is admitted, which mingles with the iron solution, decomposes it, and forms gypsum.

The wood thus paynized burns with difficulty, allows of great wear, and does not decay; alum is added to the first solution when the wood is desired to be rendered incombustible. The time required for paynizing 7000 or 8000 feet of timber (all the cylinder will contain) is from five to ten hours, depending on the size of the timber. When the process is complete the cylinder head is removed, the cars are run out with the loads of wood altered. The wood has acquired a density about one-eighth additional by the deposit of gypsum in its pores. The wood thus altered receives by mere rubbing a high polish equal to varnished wood; and button wood, common maple, and birds eye maple, are much improved in appearance, and constitute beautiful articles of furniture. The shade of the wood is darkened by the iron acting on the tannin and gallic acids of the wood. Wood thus paynized is fully protected from dry-rot, forms valuable joists and beams in fire-proof buildings, and would form a useful material in plank roads, and as sleepers for the rails to be laid upon.